# IPv6 Ready Logo Phase-2

Conformance Test Specification
IKEv2

## Technical Document

Revision 2.0.0a


*IPv6 Forum* *http://www.ipv6forum.org/*
*IPv6 Ready Logo Committee* *http://www.ipv6ready.org/*

# MODIFICATION RECORD

**Version 2.0.0** May.10, 2011

Major Version Up Items

- Change EN.I.1.2.4.1
- Change SGW.I.1.2.4.1
- Add [EN.R.P29.L2503.ADD]
- Add [SGW.R.P29.L2503.ADD]
- Add [EN.R.P86.L4030.ADD.1]
- Add [SGW.R.P86.L4030.ADD.1]
- Add [EN.R.P86.L4030.ADD.2]
- Add [SGW.R.P86.L4030.ADD.2]
- Add [EN.R.P86.L4034.ADD.1]
- Add [SGW.R.P86.L4034.ADD.1]
- Add [EN.R.P86.L4034.ADD.2]
- Add [SGW.R.P86.L4034.ADD.2]
- Add [EN.R.P57.L2663.ADD]
- Add [SGW.R.P57.L2663.ADD]
- Add [EN.R.P69.L3234.ADD]
- Add [SGW.R.P69.L3234.ADD]
- Add [EN.R.P69.L3252.ADD]
- Add [SGW.R.P69.L3252.ADD]
- Add [EN.R.P69.L3258.ADD]
- Add [SGW.R.P69.L3258.ADD]
- Add [EN.R.P69.L3260.ADD]
- Add [SGW.R.P69.L3260.ADD]
- Add [SGW.R.P116.L5437.ADD]

**Version 1.1.0** Jun. 8, 2010

Major Revision Up Items

- IKEv2.{EN,SGW}.{I,R}.1.1.6.1 Part F - Supported PRF PRF_HMAC_SHA2_256
- IKEv2.{EN,SGW}.{I,R}.1.1.6.1 Part G - Supported Integrity Algorithm AUTH_HMAC_SHA2_256_128 for IKE SA
- IKEv2.{EN,SGW}.{I,R}.1.1.6.1 Part H - Supported Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.{I.R}.1.1.6.2 Part G - Supported Integrity Algorithm AUTH_HMAC_SHA2_256_128 for Child SA
- IKEv2.{EN,SGW}.I.1.1.6.3 Part D - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.I.1.1.6.4 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.I.1.1.6.7 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.I.1.1.6.11 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.I.1.2.4.4 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.I.1.2.4.5 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.1.6.3 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.1.6.4 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.1.6.7 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.1.6.8 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.2.6.5 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24
- IKEv2.{EN,SGW}.R.1.2.6.6 - Changed to choose Diffie-Hellman Group 14 or Diffie-Hellman Group 24

Minor Revision Up Items

- IKEv2.{EN,SGW}.R.1.1.6.9 - Added IKE_SA Rekeying Failure test cases
- IKEv2.{EN,SGW}.R.1.1.4.4 Part A-D - Allowed only Notify type of UNSUPPORTED_CRITICAL_PAYLOAD
- IKEv2.{EN,SGW}.{I,R}.1.1.8.1 - Removed test cases for INVALID_IKE_SPI because of MAY requirement
- IKEv2.{EN,SGW}.R.1.1.4.2 - Changed to use IKE_SA_INIT exchange instead of CREATE_CHILD_SA exchange
- IKEv2.{EN,SGW}.R.1.1.8.2 - Removed test cases for INVALID_SYNTAX because of untestable test case
- IKEv2.{EN,SGW}.I.1.3.4.1 - Removed test cases for INVALID_SPI because of MAY requirement
- IKEv2.{EN,SGW}.R.1.1.6.9 - Changed to receive Notify type of NO_PROPOSAL_CHOSEN
- IKEv2.{EN,SGW}.I.1.1.6.8 - Removed test cases for receiving NO_PROPOSAL_CHOSEN because of untestable test case
- IKEv2.{EN,SGW}.R.1.1.7.2 - Allowed only Notify type of TS_UNACCEPTABLE
- IKEv2.{EN,SGW}.I.1.1.8.2 - Removed test cases for INVALID_SELECTORS because of MAY requirement
- IKEv2.{EN,SGW}.R.1.1.8.3 - Removed test cases for INVALID_SELECTORS because of MAY requirement
- IKEv2.{EN,SGW}.I.1.1.3.4 - Removed test cases for INITIAL_CONTACT because of MAY requirement
- IKEv2.{EN,SGW}.R.1.1.3.3 - Removed test cases for INITIAL_CONTACT because of MAY requirement
- IKEv2.{EN,SGW}.I.1.1.11.4 - Changed to use IKE_AUTH exchange instead of IKE_SA_INIT exchange
- IKEv2.{EN,SGW}.I.1.1.11.5 - Changed to use IKE_AUTH exchange instead of IKE_SA_INIT exchange
- IKEv2.{EN,SGW}.R.1.1.11.5 Part A and B- Changed to use IKE_AUTH exchange instead of IKE_SA_INIT exchange
- IKEv2.{EN,SGW}.R.1.1.5.1 - Removed test cases for COOKIE generation because of untestable test case

- IKEv2.{EN,SGW}.R.1.1.5.2 - Removed test cases for COOKIE generation because of untestable test case
- IKEv2.{EN,SGW}.R.1.1.5.3 - Removed test cases for COOKIE generation because of untestable test case
- IKEv2.{EN,SGW}.R.1.1.5.4 - Removed test cases for COOKIE generation because of untestable test case
- IKEv2.{EN,SGW}.R.1.2.8.1 - Removed test cases for AUTHENTICATION_FAILED because of untestable test case
- IKEv2.{EN,SGW}.I.1.1.6.1 Part B - Removed test cases using AES_CTR for IKE_SA negotiation
- IKEv2.{EN,SGW}R.1.1.6.1 Part B - Removed test cases using AES_CTR for IKE_SA negotiation
- IKEv2.{EN,SGW}.I.1.2.4.7 - Fixed typo
- IKEv2.EN.I.2.1.2.{2,3,4,5} - Added Possible Problems
- IKEv2.{EN,SGW}.I.1.1.6.12 - Changed to be more realistic test sequence
- IKEv2.{EN,SGW}.I.1.1.3.5 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.3.1.1 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.3.2.1 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.3.2.2 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.3.3.1 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.1.3.8 - Removed test cases for sending liveness check because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.1 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.2 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.7 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.8 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.9 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.10 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.11 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.12 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.13 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.14 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.2.6.15 - Removed test cases for exchange collision because of untestable
- IKEv2.{EN,SGW}.I.1.1.3.7 - Removed test cases for CHILD_SA deletion because of untestable
- IKEv2.SGW.I.1.1.6.10 - Fixed typo
- IKEv2.{EN,SGW}.I.1.2.3.6 - Changed to use rekeying IKE_SA instead of rekeying CHILD_SA
- IKEv2.{EN,SGW}.R.1.2.6.8 -
- IKEv2.{EN,SGW}.I.1.2.3.8 - Changed to allow both the new CHILD_SA and the old CHILD_SA
- IKEv2.{EN,SGW}.R.1.2.5.6 - Changed to allow both the new CHILD_SA and the old CHILD_SA
- IKEv2.{EN,SGW}.I.1.2.6.5 - Changed to allow both the new duplicated IKE_SA and the old IKE_SA
- IKEv2.{EN,SGW}.{I,R}.1.1.10.1 Part A, B, and C - Support 3 types of ID Types
- IKEv2.{EN,SGW}.{I,R}.1.1.10.2 Part A, B, and C - Support 3 types of ID Types
- IKEv2.{EN,SGW}.{I,R}.1.1.10.3 Part A, B, and C - Support 3 types of ID Types
- (currently not updated) add IKEv2.{EN,SGW}.R.1.2.8.1 Part C
- (currently not updated) change certificate test cases

**Version 1.0.3** Sep. 14, 2009

- IKEv2.{EN,SGW}.{I,R}.1.1.6.2 Part E - Permitted to omit transform when the integrity algorithm is NONE
- IKEv2.{EN,SGW}.I.1.1.5.[2-3], IKEv2.{EN,SGW}.I.1.1.6.{7,11}, IKEv2.{EN,SGW}.R.1.1.5.[3-4], IKEv2.{EN,SGW}.R.1.1.6.[7-8] - Updated INVALID_KE_PAYLOAD test procedure to be realistic
- IKEv2.{EN,SGW}.R.1.1.6.7 - Mandated to transmit INVALID_KE_PAYLOAD since it is required as MUST in RFC 4306
- IKEv2.{EN,SGW}.I.1.1.6.7 - Changed requirements from BASIC to ADVANCED since these tests requires NUT to transmit multiple transforms and to support 2048 MODP Group
- IKEv2.{EN,SGW}.I.1.1.6.11 - Changed requirements from BASIC to ADVANCED since these tests requires NUT to transmit multiple transforms, to support 2048 MODP Group and to support PFS
- IKEv2.{EN,SGW}.I.1.2.3.7, IKEv2.{EN,SGW}.R.1.2.5.5 - Changed requirements from BASIC to ADVANCED since these tests requires NUT to support PFS

**Version 1.0.2** Jun. 02, 2009

- Requirements - Unsupport send / receive ID_IPV4_ADDR / ID_FQDN / ID_RFC822_ADDR function by mandating to support ID_IPV6_ADDR
- {EN,SGW}.I.1.1.9.1, {EN,SGW}.I.1.1.9.2, {EN,SGW}.R.1.1.9.1, {EN,SGW}.R.1.1.9.2 - Remove send / receive ID_IPV4_ADDR / ID_FQDN / ID_RFC822_ADDR test cases by mandating to support ID_IPV6_ADDR
- Function List, {EN,SGW}.I.1.2.5.2 - Clarify Additional CHILD_SA function is ADVANCED
- EN.R.1.1.7.2 - Fix editorial typo
- {EN,SGW}.R.1.3.1.1 - Correct test Purpose
- {EN,SGW}.I.1.2.3.6 - Fix editorial typo
- EN.I.2.1.1.1, EN.I.2.1.1.2, EN.R.2.1.1.1, EN.R.2.1.1.2 - Fix editorial typo

**Version 1.0.1** Apr. 15, 2009

- IKEv2.EN.I.1.1.5.2, IKEv2.SGW.1.1.5.2, IKEv2.EN.R.1.1.5.3, IKEv2.SGW.R.1.1.5.3, IKEv2.EN.R.1.1.5.4, IKEv2.SGW.R.1.1.5.4 - Update acceptable packets and check establishment of IKE_SA
- IKEv2.EN.I.1.1.5.3, IKEv2.SGW.I.1.1.5.3 - Add new test cases for Intetaction of COOKIE and INVALID_KE_PAYLOAD with unoptimized Responder

**Version 1.0.0** Dec. 11, 2008

- Initial release

# ACKNOWLEDGMENTS

**The IPv6 Forum would like to acknowledge the efforts of the following organizations in the development of this test suite.**

**Authors:**

Yokogawa Electric Corporation
Nippon Telegraph and Telephone Corporation (NTT)

**Commentators:**

NTT Advanced Technology Corporation (NTT-AT)
University of New Hampshire - InterOperability Lab
IRISA-INRIA

**Note:**

Development of this document was supported in part by a grant from NICT.

# INTRODUCTION

## Overview

TAHI Project is the joint effort formed with the objective of developing and providing the verification technology for IPv6.

The growth process of IPv4 was the history of encountering various kinds of obstacles and conquering such obstacles. However, once the position as infrastructure was established, it is not allowed to repeat the same history.
This is a reason why the verification technology is essential for IPv6 deployment.

> We research and develop conformance tests and interoperability tests for IPv6.
>
> We closely work with the KAME project and USAGI project.
> We help activities of these projects in the quality side by offering the verification technology we develop in TAHI project and improve the development efficiency.
>
> We open the results and fruits of the project to the public for FREE.
> Any developer concerned with IPv6 can utilize the results and fruits of TAHI project freely.
> Free software plays an important role in progress of the Internet. We believe that providing the verification technology for FREE contributes to advances of IPv6.
> Besides the programs, the specifications and criteria of verification will be included in the Package.

## Abbreviations and Acronyms

| | |
|---|---|
| **TN:** | Testing Node |
| **TH:** | Testing Host |
| **TR:** | Testing Router |
| **NUT:** | Node Under Test |
| **HUT:** | Host Under Test |
| **RUT:** | Router Under Test |
| **IKE:** | Internet Key Exchange (IKEv2) Protocol |
| **EN:** | End-Node |
| **SGW:** | Security-Gateway |
| **PSK:** | Pre-Shared Key |
| **AUTH:** | Authentication Payload |
| **CERT:** | Certificate Payload |
| **CERTREQ:** | Certificate Request Payload |
| **CP:** | Configuration Payload |
| **D:** | Delete Payload |
| **E:** | Encrypted Payload |
| **EAP:** | Extensible Authentication Payload |
| **HDR:** | IKE Header |
| **IDi:** | Identification - Initiator Payload |
| **IDr:** | Identification - Responder Payload |
| **KE:** | Key Exchange Payload |
| **Ni:** | Nonce - Initiator Payload |
| **Nr:** | Nonce - Responder Payload |
| **N:** | Notify Payload |
| **SA:** | Security Association Payload |
| **TSi:** | Traffic Selector - Initiator Payload |
| **TSr:** | Traffic Selector - Responder Payload |
| **V:** | Vendor ID Payload |

# TEST ORGANIZATION

This document organizes tests by Section based on related test methodology or goals. Each group begins with a brief set of comments pertaining to all tests within that group. This is followed by a series of description blocks; each block describes a single test. The format of the description block is as follows:

| | |
|---|---|
| **Test Label:** | The test label and title comprise the first line of the test block. The test label is composed by concatenating the short test suite name, the section number, the group number, and the test number within the group. These elements are separated by periods. The Test Number is the section, group and test number, also separated by periods. |
| **Purpose:** | The Purpose is a short statement describing what the test attempts to achieve. It is usually phrased as a simple assertion of the feature or capability to be tested. |
| **References:** | The References section lists cross-references to the specifications and documentation that might be helpful in understanding and evaluating the test and results. |
| **Resource Requirements:** | The Resource Requirements section specifies the software, hardware, and test equipment that will be needed to perform the test. |
| **Test Setup:** | The Test Setup section describes the configuration of all devices prior to the start of the test. Different parts of the procedure may involve configuration steps that deviate from what is given in the test setup. If a value is not provided for a protocol parameter, then the protocol's default is used for that parameter. |
| **Procedure:** | This section of the test description contains the step-by-step instructions for carrying out the test. These steps include such things as enabling interfaces, unplugging devices from the network, or sending packets from a test station. The test procedure also cues the tester to make observations, which are interpreted in accordance with the observable results given for that test part. |
| **Observable Results:** | This section lists observable results that can be examined by the tester to verify that the NUT is operating properly. When multiple observable results are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail for each test is usually based on how the NUT's behavior compares to the results described in this section. |
| **Possible Problems:** | This section contains a description of known issues with the test procedure, which may affect test results in certain situations. |

# REFERENCES

The following documents are referenced in this text:

- RFC 4306 - Internet Key Exchange (IKEv2) Protocol, December, 2005.
- RFC 4307 - Cryptographic Algorithms for Use in the Internet Key Exchange Version 2 (IKEv2), December, 2005
- RFC 4718 - IKEv2 Clarifications and Implementation Guidelines, October, 2006

# TABLE OF CONTENTS

## Requirements

To obtain the IPv6 Ready Logo Phase-2 for IKEv2, the Node Under Test (NUT) must satisfy all of the following requirements.

### Equipment Type

There are two possibilities for equipment types:

End-Node:
: A node who can use IKEv2 (IPsec) only for itself. Host and Router can be an End-Node.

SGW (Security Gateway):
: A node who can provide IKEv2 (IPsec tunnel mode) for nodes behind it. Router can be a SGW.

### Function List

#### Basic/Advanced Functionality table

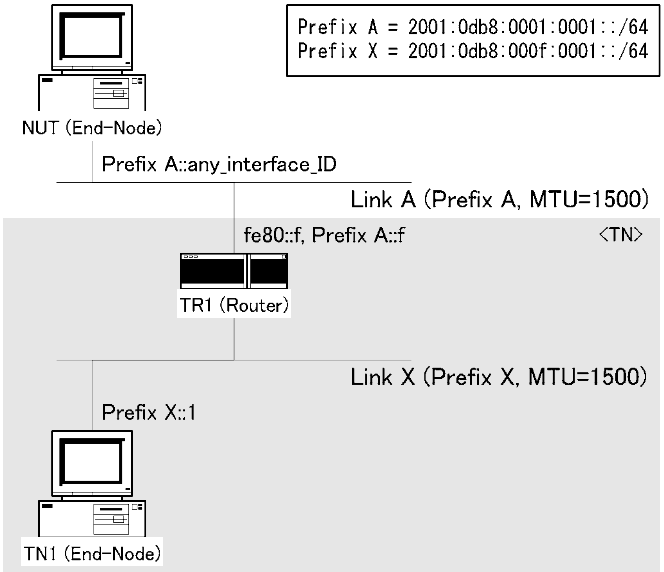
This conformance test specification consists following BASIC/ADVANCED functions.
The tests for ADVANCED functions may be omitted if the NUT does not support the ADVANCED function.
All NUTs are required to support BASIC. ADVANCED is required for all NUTs which support ADVANCED function.

| Parameter | | BASIC | ADVANCED |
|---|---|---|---|
| Exchange Type | | Initial Exchanges (IKE_INIT, IKE_AUTH) | - |
| | | CREATE_CHILD_SA | - |
| | | INFORMATIONAL | - |
| IKE_SA | Encryption Algorithm | ENCR_3DES | ENCR_AES_CBC<br>ENCR_AES_CTR |
| | Pseudo-random Function | PRF_HMAC_SHA1 | PRF_AES128_XCBC |
| | Integrity Algorithm | AUTH_HMAC_SHA1_96 | AUTH_AES_XCBC_96 |
| | Diffie-Hellman Group | 2 (1024 MODP Group) | 14 (2048-bit MODP Group)<br>24 (2048-bit MODP Group with 256-bit Prime Order Subgroup) |
| CHILD_SA | Encryption Algorithm | ENCR_3DES | ENCR_AES_CBC<br>ENCR_AES_CTR<br>ENCR_NULL |
| | Integrity Algorithm | AUTH_HMAC_SHA1_96 | AUTH_AES_XCBC_96<br>NONE |
| | Extended Sequence Numbers | No Extended Sequence Numbers | Extended Sequence Numbers |
| Authentication Method | | PSK | - |
| Security Protocol | | ESP | - |
| Encapsulation mode | End-Node | Transport | Tunnel |
| | SGW | Tunnel | - |
| Multiple Proposals | | Receiving | Sending |
| Multiple Transforms | | Receiving | Sending |
| Liveness Check | | Support | - |

| | | |
|---|---|---|
| Cookies | - | Support |
| Rekeying | Support | - |
| Traffic Selector Negotiation | Support | - |
| Requesting an Internal Address on a Remote Network | - | Support |
| Perfect Forward Secrecy | - | Support |
| Closing SAs | Support | - |
| ID Type | ID_IPV6_ADDR | - |
| Creating additional CHILD_SA | - | Support |

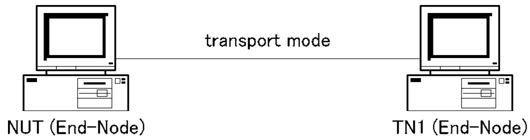
# Common Topology

## Common Topology for End-Node: End-Node to End-Node

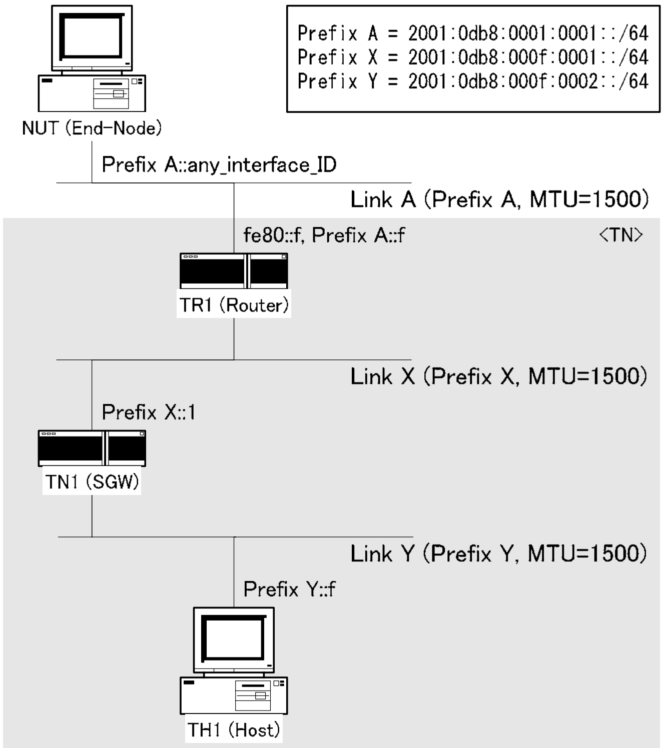



The common topology involves End-Nodes and Router device on each link.

The transport mode is used in this topology.

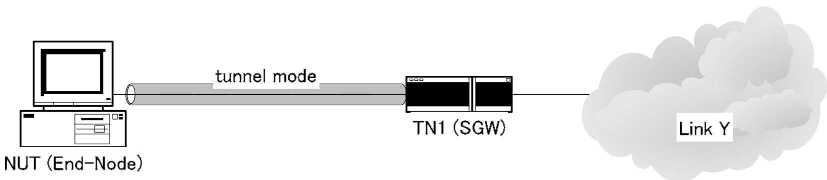


## Common Topology for End-Node: End-Node to SGW

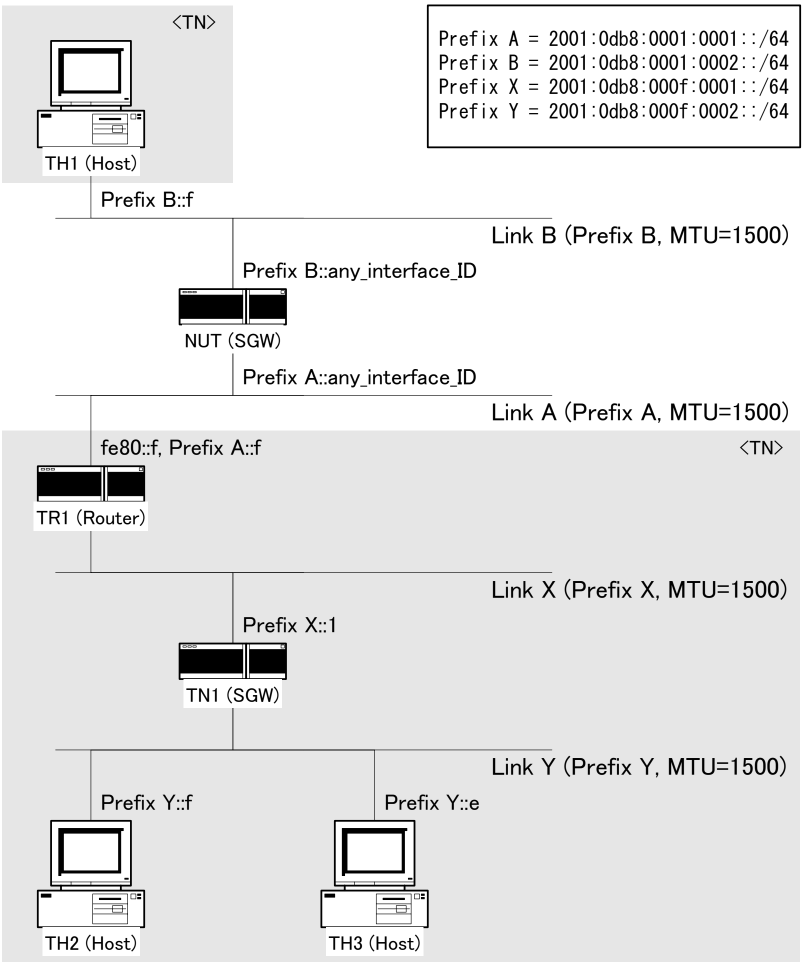



The common topology involves End-Node, SGW and Router device on each link.

The tunnel mode is used in this topology.

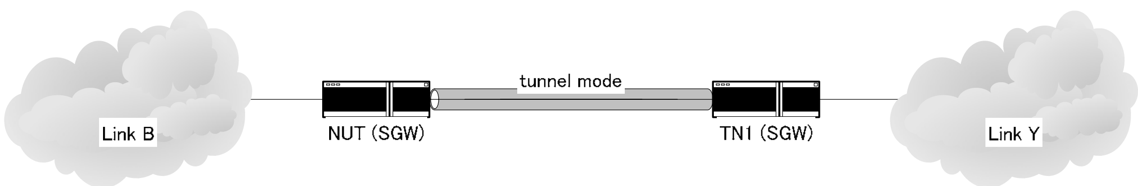


## Common Topology for SGW: SGW to SGW

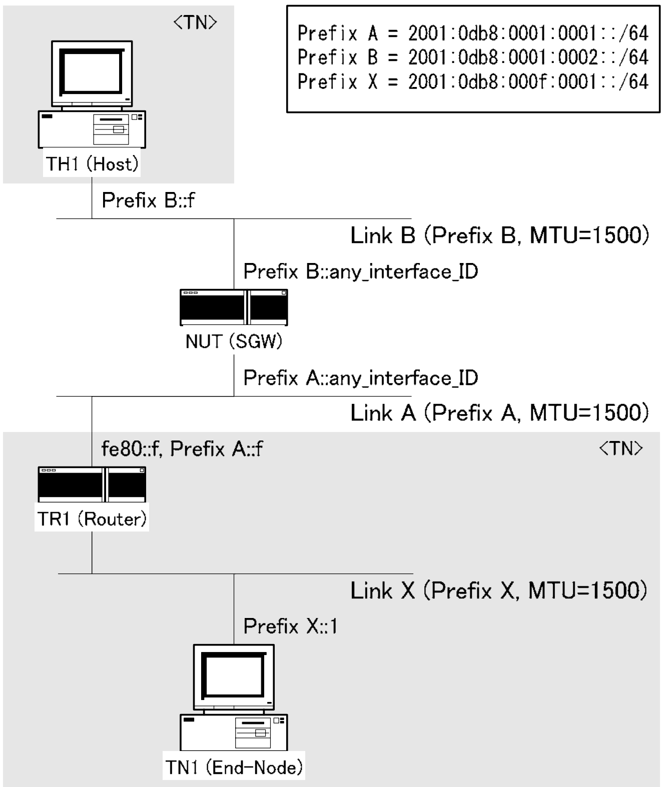



The common topology involves SGWs, Router and Host device on each link.

The tunnel mode is used in this topology.

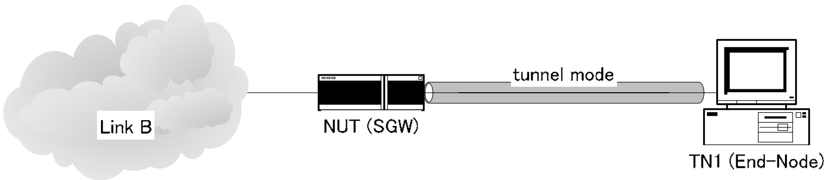


## Common Topology for SGW: SGW to End-Node




The common topology involves End-Node, SGW, Router and Host device on each link.

The tunnel mode is used in this topology.



# Common Configuration for NUT

## Common Configuration for End-Node: End-Node to End-Node

### IKE Peer

| | Address | Port | Authentication | | ID | |
|---|---|---|---|---|---|---|
| | | | Method | Key Value | Type | Data |
| **Local** | NUT | 500 | PSK | IKETEST12345678! | ID_IPV6_ADDR | NUT |
| **Remote** | TN1 | 500 | PSK | IKETEST12345678! | ID_IPV6_ADDR | TN1 |

### IKE_SA

| Algorithms | | | |
|---|---|---|---|
| Encryption | PRF | Integrity | Diffie-Hellman |
| ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | 2 (1024 MODP Group) |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

### CHILD_SA

| | Security Protocol | Mode | Algorithms | | |
|---|---|---|---|---|---|
| | | | Encryption | Integrity | Extended Sequence Numbers |
| **Inbound** | ESP | Transport | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Outbound** | ESP | Transport | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 | ANY | ANY | NUT | ANY | ANY |
| **Outbound** | NUT | ANY | ANY | TN1 | ANY | ANY |

If NUT is the initiator, NUT must propose Traffic Selector covering above address range.
If NUT is the responder, NUT must narrow Traffic Selector to above address range.

## Common Configuration for End-Node: End-Node to SGW

### IKE Peer

| | Address | Port | Authentication | | ID | |
|---|---|---|---|---|---|---|
| | | | Method | Key Value | Type | Data |
| **Local** | NUT | 500 | PSK | IKETEST123! | ID_IPV6_ADDR | NUT |
| **Remote** | TN1 (Link X) | 500 | PSK | IKETEST456! | ID_IPV6_ADDR | TN1 (LinkX) |

### IKE_SA

| Algorithms | | | |
|---|---|---|---|
| **Encryption** | **PRF** | **Integrity** | **Diffie-Hellman** |
| ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | 2 (1024 MODP Group) |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

### CHILD_SA

| | Security Protocol | Mode | Algorithms | | |
|---|---|---|---|---|---|
| | | | Encryption | Integrity | Extended Sequence Numbers |
| **Inbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Outbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | Link Y | ANY | ANY | NUT | ANY | ANY |
| **Outbound** | NUT | ANY | ANY | Link Y | ANY | ANY |

If NUT is the initiator, NUT must propose Traffic Selector covering above address range.
If NUT is the responder, NUT must narrow Traffic Selector to above address range.

## Common Configuration for SGW: SGW to SGW

### IKE Peer

| | Address | Port | Authentication | | ID | |
|---|---|---|---|---|---|---|
| | | | Method | Key Value | Type | Data |
| **Local** | NUT (Link A) | 500 | PSK | IKETEST123! | ID_IPV6_ADDR | NUT (Link A) |
| **Remote** | TN1 (Link X) | 500 | PSK | IKETEST456! | ID_IPV6_ADDR | TN1 (Link X) |

### IKE_SA

| Algorithms | | | |
|---|---|---|---|
| **Encryption** | **PRF** | **Integrity** | **Diffie-Hellman** |
| ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | 2 (1024 MODP Group) |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

### CHILD_SA

| | Security Protocol | Mode | Algorithms | | |
|---|---|---|---|---|---|
| | | | Encryption | Integrity | Extended Sequence Numbers |
| **Inbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Outbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | Link Y | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | Link Y | ANY | ANY |

If NUT is the initiator, NUT must propose Traffic Selector covering above address range.
If NUT is the responder, NUT must narrow Traffic Selector to above address range.

## Common Configuration for SGW: SGW to End-Node

### IKE Peer

| | Address | Port | Authentication | | ID | |
|---|---|---|---|---|---|---|
| | | | Method | Key Value | Type | Data |
| **Local** | NUT (Link A) | 500 | PSK | IKETEST123! | ID_IPV6_ADDR | NUT (Link A) |
| **Remote** | TN1 | 500 | PSK | IKETEST456! | ID_IPV6_ADDR | TN1 |

### IKE_SA

| Algorithms | | | |
|---|---|---|---|
| **Encryption** | **PRF** | **Integrity** | **Diffie-Hellman** |
| ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | 2 (1024 MODP Group) |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

### CHILD_SA

| | Security Protocol | Mode | Algorithms | | |
|---|---|---|---|---|---|
| | | | Encryption | Integrity | Extended Sequence Numbers |
| **Inbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Outbound** | ESP | Tunnel | ENCR_3DES | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |

If NUT is the initiator, above proposal must be one of proposals from NUT.
If NUT is the responder, NUT must select above proposal.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 | ANY | ANY |

If NUT is the initiator, NUT must propose Traffic Selector covering above address range.
If NUT is the responder, NUT must narrow Traffic Selector to above address range.

# Common Packets

Common Packets to be transmitted from Tester are defined as the following tables.Tests in this test specification may refer to these common packets.

## IKE_SA_INIT Messages

### Common Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | Any |
| | IKE_SA Responder's SPI | 0 |
| | Next Payload | 33 (SA) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 34 (IKE_SA_INIT) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 1 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| SA Payload | Next Payload | 34 (KE) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Table below |
| KE Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |
| | Key Exchange Data | any |
| Ni, Nr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 34 (KE) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 1 (IKE) |
| | | | SPI Size | | 0 |
| | | | # of Transforms | | 4 |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Transform Type | 2 (PRF) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

## Common Packet #2: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | Any |
| | Next Payload | 33 (SA) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 34 (IKE_SA_INIT) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| SA Payload | Next Payload | 34 (KE) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Table below |
| KE Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |
| | Key Exchange Data | any |
| Ni, Nr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 34 (KE) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 1 (IKE) |
| | | | SPI Size | | 0 |
| | | | # of Transforms | | 4 |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 2 (PRF) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |

| | | | | | |
|---|---|---|---|---|---|
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

## IKE_AUTH Messages

### Common Packet #3: IKE_AUTH request for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 35 (IKE_AUTH) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 1 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 1 |
| | Length | any |
| E Payload | Next Payload | 35 (IDi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| IDi Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391 (USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Table below |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

- TSr Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

## Common Packet #4: IKE_AUTH response for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 35 (IKE_AUTH) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 1 |
| | Length | any |
| E Payload | Next Payload | 36 (IDr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| IDr Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391(USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Traffic Selectors | See Traffic Selector Table below |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- TSr Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

## Common Packet #5: IKE_AUTH request for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 35 (IKE_AUTH) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 1 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 1 |
| | Length | any |
| E Payload | Next Payload | 35 (IDi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| IDi Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | |
|---|---|---|
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |

| | | | | | |
|---|---|---|---|---|---|
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSr Payload for End-Node to SGW test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT’s Global Address on Link A |
| | | Ending Address | NUT’s Global Address on Link A |

- TSi Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |

| | | | |
|---|---|---|---|
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- TSi Payload for SGW to End-Node test cases

| TSi Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

- TSr Payload for SGW to End-Node test cases

| TSr Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

## Common Packet #6: IKE_AUTH response for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 35 (IKE_AUTH) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 1 |
| | Length | any |
| E Payload | Next Payload | 36 (IDr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| IDr Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | |
|---|---|---|
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- TSr Payload for End-Node to SGW test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSi Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| | |
|---|---|
| TSr Payload | |

| | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSi Payload for SGW to End-Node test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to End-Node test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1’s Global Address on Link X |
| | | Ending Address | TN1’s Global Address on Link X |

## CREATE_CHILD_SA Messages for Generating CHILD_SA

### Common Packet #7: CREATE_CHILD_SA request for Generating CHILD_SA for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391(USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

- TSr Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

## Common Packet #8: CREATE_CHILD_SA response for Generating CHILD_SA for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391 (USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | |
|---|---|---|
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| TSi Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- TSr Payload for End-Node to End-Node test cases

| TSr Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

## Common Packet #9: CREATE_CHILD_SA request for Generating CHILD_SA for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | | | |
|---|---|---|---|---|
| SA Payload | Next Payload | | | 44 (TSi) |
| | Critical | | | 0 |
| | Reserved | | | 0 |
| | Payload Length | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Proposal Length | 36 |
| | | | Proposal # | 1 |
| | | | Proposal ID | 3 (ESP) |

| | | | | | |
|---|---|---|---|---|---|
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

## Common Packet #10: CREATE_CHILD_SA response for Generating CHILD_SA for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | any |
| | Encrypted IKE Payloads | any |
| | Padding | any |
| | Pad Length | any |
| | Integrity Checksum Data | any |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | | | |
|---|---|---|---|---|
| SA Payload | Next Payload | | | 44 (TSi) |
| | Critical | | | 0 |
| | Reserved | | | 0 |
| | Payload Length | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Proposal Length | 36 |
| | | | Proposal # | 1 |
| | | | Proposal ID | 3 (ESP) |
| | | | SPI Size | 4 |

| | | | | | |
|---|---|---|---|---|---|
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for SGW to SGW test cases

| TSi Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| TSr Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

## CREATE_CHILD_SA Messages for Rekeying IKE_SA

### Common Packet #11: CREATE_CHILD_SA request for Rekeying IKE_SA

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 44 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 34 (KE) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 1 (IKE) |
| | | | SPI Size | | 0 |
| | | | # of Transforms | | 4 |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 2 (PRF) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

## Common Packet #12: CREATE_CHILD_SA response for Rekeying IKE_SA

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 44 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 34 (KE) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 1 (IKE) |
| | | | SPI Size | | 0 |
| | | | # of Transforms | | 4 |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 2 (PRF) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

**CREATE_CHILD_SA Messages for Rekeying CHILD_SA**

## Common Packet #13: CREATE_CHILD_SA request for Rekeying CHILD_SA for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| N Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | Notify Message Type | 16393 (REKEY_SA) |
| | SPI | any |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391 (USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffice Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffice Selectors | See TSr Payload Table below |

- SA Payload

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

- TSr Payload for End-Node to End-Node test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

## Common Packet #14: CREATE_CHILD_SA response for Rekeying CHILD_SA for Transport Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum ofthe entire message |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16391 (USE_TRANSPORT_MODE) |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffice Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffice Selectors | See TSr Payload Table below |

- SA Payload

| | | |
|---|---|---|
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for End-Node to End-Node test cases

| TSi Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- TSr Payload for End-Node to End-Node test cases

| TSr Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

## Common Packet #15: CREATE_CHILD_SA request for Rekeying CHILD_SA for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| N Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | Notify Message Type | 16393 (REKEY_SA) |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table below |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | |
|---|---|---|
| SA Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | Reserved | | | | 0 |
| | Payload Length | | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 36 |
| | | | Proposal # | | 1 |
| | | | Proposal ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:ffff:ffff:ffff:ffff |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

## Common Packet #16: CREATE_CHILD_SA response for Rekeying CHILD_SA for Tunnel Mode

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 36 (CREATE_CHILD_SA) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| SA Payload | Next Payload | 40 (Ni, Nr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 40 |
| | SA Proposals | See SA Payload Table |
| Ni, Nr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Nonce Data | any |
| TSi Payload | Next Payload | 45 (TSr) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSi Payload Table below |
| TSr Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 48 |
| | Number of TSs | 1 |
| | Reserved | 0 |
| | Traffic Selectors | See TSr Payload Table below |

- SA Payload

| | | | | |
|---|---|---|---|---|
| SA Payload | Next Payload | | | 44 (TSi) |
| | Critical | | | 0 |
| | Reserved | | | 0 |
| | Payload Length | | | 40 |
| | Proposal #1 | SA Proposal | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Proposal Length | 36 |
| | | | Proposal # | 1 |
| | | | Proposal ID | 3 (ESP) |
| | | | SPI Size | 4 |

| | | | | | |
|---|---|---|---|---|---|
| | | | # of Transforms | | 3 |
| | | | SPI | | any |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 1 (ENCR) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 3 (3DES) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (ESN) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No ESN) |

- TSi Payload for SGW to SGW test cases

| TSi Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- TSr Payload for SGW to SGW test cases

| TSr Payload | | | |
|---|---|---|---|
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

## INFORMATIONAL Messages

### Common Packet #17: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The IKE_SA Initiator's SPI value used by this IKE message |
| | IKE_SA Responder's SPI | The IKE_SA Responder's SPI value used by this IKE message |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The value incremented the previous IKE message's Message ID by one. If this message is first one, this value is set to 0. |
| | Length | any |
| E Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |

## Common Packet #18: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | The same value as corresponding request's IKE_SA Responder's SPI value |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The cryptographic checksum of the entire message |

## ICMPv6 Echo Requests

### Common Packet #19: ICMPv6 Echo Request for End-Node to End-Node test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address |
| | Destination Address | NUT's Global Address |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 58 (IPV6-ICMP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | 0 |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #20: ICMPv6 Echo Request for End-Node to SGW test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | NUT's Global Address on Link A |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #21: ICMPv6 Echo Request for SGW to SGW test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH2's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #22: ICMPv6 Echo Request for SGW to End-Node test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address |

| | | |
|---|---|---|
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA’s SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet’s Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 58 (IPV6-ICMP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TN1's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

## ICMPv6 Echo Replys

### Common Packet #23: ICMPv6 Echo Reply for End-Node to End-Node test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address |
| | Destination Address | NUT's Global Address |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 58 (IPV6-ICMP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #24: ICMPv6 Echo Reply for End-Node to SGW test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | NUT's Global Address on Link A |
| | Destination Address | TN1's Global Address on Link X |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | NUT's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #25: ICMPv6 Echo Reply for SGW to SGW test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | TH2's Global Address |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

### Common Packet #26: ICMPv6 Echo Reply for SGW to End-Node test cases

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | TN1's Global Address |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |
| | Identifier | Any |
| | Sequence Number | Any |
| | Payload Data | 0x0000000000000000 |

# Section 1. End Node
## Section 1.1. Initiator
### Section 1.1.1. Endpoint-to-Endpoint Transport
#### Group 1. The Initial Exchanges

# Group 1.1. Header and Payload Formats

## Test IKEv2.EN.I.1.1.1.1: Sending IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device transmits IKE_SA_INIT request using properly Header and Payloads format.

**References:**

- [RFC4306] - Section 1.2, 2.10, 3.1, 3.2, 3.3, 3.4 and 3.9
- [RFC 4718] - Sections 7.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)       (End-Node)
    |                 |
    |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |                 |
    V                 V
```

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B: SA Payload Format (BASIC)*

3. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C: KE Payload Format (BASIC)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

*Part D: Nonce Payload Format (BASIC)*

7. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 1 Header format**

- An IKE_SA Initiator's SPI field set to a 64-bits value chosen by the NUT. It MUST not be zero.
- An IKE_SA Responder's SPI field set to zero.
- A Next Payload field set to SA Payload (33).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to IKE_SA_INIT (34).
- A Flags field is set to (00010000)2 = (16)10.
- A Message ID field is set to zero.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 4: Judgment #1**

```
                                 1                   2                   3
               0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ------------
              ! Next     34    !0!       0      ! Length          44            !            |
              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---        |
              !       0       !       0       ! Length          40            ! |          |
              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
              ! Number     1  ! Prot ID    1  ! SPI Size   0  ! Trans Cnt  4  ! |          |
          --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | !       3       !       0       ! Length          8             ! |          |
Transform   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | ! Type  1  (EN) !       0       ! Transform ID     3      (3DES) ! |          |
          --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | !       3       !       0       ! Length          8             ! |          |SA Payload
Transform   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |Proposal  |
            | ! Type  2  (PR) !       0       ! Transform ID     2      (SHA1) ! |          |
          --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | !       3       !       0       ! Length          8             ! |          |
Transform   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | ! Type  3  (IN) !       0       ! Transform ID     2      (SHA1) ! |          |
          --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | !       0       !       0       ! Length          8             ! |          |
Transform   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            | ! Type  4  (DH) !       0       ! Transform ID     2      (1024) ! |          |
          --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ------------
```

**Figure 2 SA Payload contents**

The NUT transmits an IKE_SA_INIT request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 3 SA Payload format**

- A Next Payload field is set to KE Payload (34).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 4 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 40 bytes for this proposal according to Common Configuration.
- A Proposal # field is set to 1 if this structure is the first proposal, otherwise set to 1 greater than the previous proposal.
- A Protocol ID field is set to IKE (1).
- A SPI Size field is set to zero.
- A # of Transforms field is set to 4.

A Transform field is set to following (There are 4 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 5 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for PRF_HMAC_SHA1.
- A Transform Type field is set to PRF (2).
- A RESERVED field is set to zero.
- A Transform ID set to PRF_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #4

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for 1024 MODP Group.
- A Transform Type field is set to D-H (4).
- A RESERVED field is set to zero.
- A Transform ID set to Group2 (2).

*Part C*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT request including properly formatted KE Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!          DH Group #           !           RESERVED            !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Key Exchange Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 6 KE Payload format**

- A Next Payload field is set to Nonce Payload (40).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 136 bytes for Group 2.
- A DH Group field is set to Group2 (2).
- A RESERVED field is set to zero.
- A Key Exchange Data field is set to Diffie-Hellman public value. The length of the Key Exchange Data field must be equal to 1024bit.

*Part D*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT request including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 7 Nonce Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Nonce Data field is set to random data generated by the transmitting entity. The size of the Nonce must between 16 and 256 octets.

**Possible Problems:**

- IKE_SA_INIT request has following packet format. It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(COOKIE)],
SA, KE, Ni,
[N(NAT_DETECTION_SOURCE_IP)+,
 N(NAT_DETECTION_DESTINATION_IP)],
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- Each of transforms can be located in the any order.

## Test IKEv2.EN.I.1.1.1.2: Sending IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH request using properly Header and Payloads format.

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)      (End-Node)
     |               |
     |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |               | (Judgment #1)
     |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |               | (Packet #1)
     |               |
     |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |               | (Judgment #2)
     |               |
     V               V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: IDi Payload Format (BASIC)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.

11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (BASIC)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: Notify Payload Format (BASIC)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: SA Payload Format (BASIC)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSi Payload Format (BASIC)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link A.

*Part H: TSr Payload Format (BASIC)*

29. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
30. Observe the messages transmitted on Link A.
31. TN1 responds with an IKE_SA_INIT response to the NUT.
32. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 8 Header format**

- An IKE_SA Initiator’s SPI field is set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field is set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field is set to Encrypted Payload (46).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to IKE_AUTH (35).
- A Flags field is set to (00010000)2 = (16)10.
- A Message ID field is set to 1.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 9 Encrypted payload**

- A Next Payload field is set to IDi Payload (35).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 10 ID Payload format**

- A Next Payload field is set to AUTH Payload (39).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field is set to ID_IPV6_ADDR (5).
- A RESERVED field is set to zero.
- An Identification Data field is set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 11 AUTH Payload format**

- A Next Payload field is set to Notify Payload (41).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field is set to Shared Key Message Integrity Code (2).
- A RESERVED field is set to zero.
- An Authentication Data field is set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 12 Notify Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 8 bytes for USE_TRANSPORT_MODE.
- A Protocol ID field is set to undefined (0).
- A SPI Size field is set to zero.
- A Notify Message Type field is set to USE_TRANSPORT_MODE (16391)

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**

```
                                 1                   2                   3
             0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
            ! Next     44   !0!      0      ! Length         40             !              |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
            !       0       !        0      ! Length         36             !  |           |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
            ! Number     1  ! Prot ID    3  ! SPI Size   4  ! Trans Cnt  3  !  |           |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
            ! SPI value                                                     !  |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          | !       3       !        0      ! Length          8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
          | ! Type  1  (EN) !        0      ! Transform ID    3     (3DES)  !  | Proposal  |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          | !       3       !        0      ! Length          8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          | ! Type  3  (IN) !        0      ! Transform ID    2     (SHA1)  !  |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          | !       0       !        0      ! Length          8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          | ! Type  5  (ESN)!        0      ! Transform ID    0      (No)   !  |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 13 SA Payload contents**

The NUT transmits an IKE_AUTH request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 14 SA Payload format**

- A Next Payload field is set to TSi Payload (44).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 15 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field is set to 1 if this structure is the first proposal, otherwise set to 1 greater than the previous proposal.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to 4.
- A # of Transforms field is set to 3.
- A SPI field is set to the sending entity's SPI (4 octets value)

Transform field is set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 16 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field is set to ESN (5).
- A RESERVED field is set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part G*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 17 TSi Payload format**

- A Next Payload field is set to TSr Payload (45).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to the number of actual traffic selectors.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 18 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to NUT address.
- A Ending Address field is set to greater thatn or equal to NUT address.

*Part H*

**Step 30: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 32: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 19 TSr Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to the number of actual traffic selectors.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 20 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to TN1 address.
- An Ending Address field is set to less than or equal to TN1 address.

**Possible Problems:**

- IKE_AUTH request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDi,
[CERT+],
[N(INITIAL_CONTACT)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)], CERTREQ+],
[IDr],
AUTH,
[CP(CFG_REQUEST)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA,
TSi,
TSr,
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.
- Each of transforms can be located in the any order.
- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

### Test IKEv2.EN.I.1.1.1.3: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Packet #2)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #3)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #3)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.

7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

# Group 1.2. Use of Retransmission Timers

## Test IKEv2.EN.I.1.1.2.1: Retransmissions of IKE_SA_INIT requests

**Purpose:**

To verify an IKEv2 device retransmits IKE_SA_INIT request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |                |
    |                * wait for the event of a timeout
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #2)
    |                |
    V                V
```

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 waits for the event of a timeout on NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Test IKEv2.EN.I.1.1.2.2: Stop of retransmission of IKE_SA_INIT requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Judgment #1)
     |                |
     |                * wait for the event of a timeout
     |                |
     |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Judgment #2)
     |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Packet #1)
     |                |
     |                * wait for the event of a timeout
     |                |
     |-------X        | never send IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Judgment #3)
     |                |
     V                V
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 waits for the event of a timeout on NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response to the NUT.
6. TN1 waits for the event of a timeout on NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Step 7: Judgment #3**
The NUT never retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Test IKEv2.EN.I.1.1.2.3: Retransmissions of IKE_AUTH requests

**Purpose:**

To verify an IKEv2 device retransmits IKE_AUTH request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |                * wait for the event of a timeout
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 waits for the event of a timeout on NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Test IKEv2.EN.I.1.1.2.4: Stop of retransmission of IKE_AUTH requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                TN1
 (End-Node)        (End-Node)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                  | (Judgment #1)
     |<-----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                  | (Packet #1)
     |                  |
     |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                  | (Judgment #2)
     |                  |
     |                  * wait for the event of a timeout
     |                  |
     |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                  | (Judgment #3)
     |<-----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                  | (Packet #2)
     |                  |
     |                  * wait for the event of a timeout
     |                  |
     |-------X          | never send IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                  | (Judgment #4)
     |                  |
     V                  V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.

4. Observe the messages transmitted on Link A.
5. TN1 waits for the event of a timeout on NUT.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_AUTH response to the NUT.
8. TN1 waits for the event of a timeout on NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Step 9: Judgment #4**
The NUT never retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Group 1.3. State Synchronization and Connection Timeouts

### Test IKEv2.EN.I.1.1.3.1: State Synchronization with ICMP messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives ICMP messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT            TR1            TN1
(End-Node)      (Router)      (End-Node)
    |              |              |
    |--------------+------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |              |              | (Judgment #1)
    |<-------------+--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |              |              | (Packet #1)
    |              |              |
    |--------------+------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |              |              | (Judgment #2)
    |<-------------+--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |              |              | (Packet #2)
    |              |              |
    |<-------------+--------------| IPsec {Echo Request}
    |              |              | (Packet #3)
    |--------------+------------->| IPsec {Echo Reply}
    |              |              | (Judgment #3)
    |              |              |
    |<-------------|              | ICMPv6 Destination Unreachable (No route to destination)
    |              |              | (Packet #4)
    |              |              |
    |<-------------+--------------| IPsec {Echo Request}
    |              |              | (Packet #5)
    |--------------+------------->| IPsec {Echo Reply}
    |              |              | (Judgment #4)
    |              |              |
    V              V              V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

| | |
|---|---|
| Packet #4 | See below |
| Packet #5 | See Common Packet #19 |

Packet #4: ICMPv6 Destination Unreachable

| | | |
|---|---|---|
| IPv6 Header | Source Address | TR1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link A |
| ICMPv6 Header | Type | 1 |
| | Code | 0 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. After reception of an Echo Reply from NUT, TR1 transmits ICMP Destination Unreachable Message to the NUT and then TN1 transmits an Echo Request to the NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.3.2: State Synchronization with IKE messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives IKE messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Packet #2)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #2)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #3)
    |               |
    |<--------------| cryptographically unprotected IKE message
    |               | (Packet #3)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #4)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #4)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See below |
| Packet #4 | See Common Packet # 20 |

Packet #3: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link X |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | any |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 0 |
| | Notify Message Type | 11 (INVALID_SPI) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. TN1 transmits a cryptographically unprotected INFORMATIONAL request with Notify payload of type INVALID_ SPI to the NUT.
9. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #4**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None

Test IKEv2.EN.I.1.1.3.3: Close connections when repeated attempts fail

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                TN1
(End-Node)         (End-Node)
    |                  |
    |----------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Judgment #1)
    |<-----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Packet #1)
    |                  |
    |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    |                  * wait for the event of a timeout
    |                  |
    |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Judgment #3)
    |                  |
    |                  * wait for the event of a timeout
    |                  |
    |-------X          | never send IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Judgment #3)
    |                  |
    V                  V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 waits for the event of a timeout on the NUT.
6. Observe the messages transmitted on Link A.
7. Repeat Step 5 and Step 6 until the NUT's last restransmission comes.

8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Step 8: Judgment #4**
The NUT never retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Possible Problems:**

- None.

### Test IKEv2.EN.I.1.1.3.4: Close connections when receiving INITIAL_CONTACT

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.1.3.5: Sending Liveness check

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.1.3.6: Sending Delete Payload for IKE_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when IKE_SA is deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 30 seconds.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |                * wait until expiring IKE_SA
    |                |
    |--------------->| INFORMATIONAL request (HDR, SK {D})
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 waits until expiring IKE_SA's lifetime and does not respond to an INFORMATIONAL request with an INFORMATIONAL response for liveness check.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Possible Problems:**

- At Step 7, NUT can transmit INFORMATIONAL request with a Delete Payload including 2 (ESP) as Protocol ID, 4 as SPI Size and SPI value to delete CHILD_SA before transmitting an INFORMATIONAL request to delete IKE_SA.

## Test IKEv2.EN.I.1.1.3.7: Sending Delete Payload for CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.1.3.8: Sending Liveness check with unprotected messages

This test case was deleted at revision 1.1.0.

# Group 1.4. Version Numbers and Forward Compatibility

## Test IKEv2.EN.I.1.1.4.1: Unrecognized payload types and Critical bit is not set

**Purpose:**

To verify an IKEv2 device ignores invalid payload types when the invalid type payload's critical bit is not set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                TN1
(End-Node)        (End-Node)
    |                 |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                 | (Packet #2)
    |                 |
   ...               ...
    |                 |                          ---
    |<--------------| IPsec {Echo Request}        |
    |                 | (Packet #3)                 |
    |-------------->| IPsec {Echo Reply}          | repeat Echo exchange until lifetime of SA is expired
    |                 | (Judgment #3)               |
    |                 |                          ---
   ...               ...
    |                 |
    |-------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Judgment #4)
    |<--------------| CREATE_CHILD_SA response (HDR, SK {P, N+, SA, Nr, TSi, TSr})
    |                 | (Packet #4)
    |                 |
    |<--------------| IPsec {Echo Request} (new CHILD_SA)
    |                 | (Packet #5)
    |-------------->| IPsec {Echo Reply} (new CHILD_SA)
    |                 | (Judgment #5)
    |                 |
    V                 V

P: Payload with an invalid payload type
N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |
| Packet #5 | See Common Pakcet #19 |

Packet #4: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #14 Payload | |
| UDP Header | All fields are same as Common Packet #14 Payload | |
| IKEv2 Header | All fields are same as Common Packet #14 Payload | |
| E payload | Next Payload | *Invalid payload type value* |
| | Other fields are same as Common Packet #14 | |
| Invalid Payload | Next Payod | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 4 |
| N Payload | All fields are same as Common Packet #14 Payload | |
| SA Payload | All fields are same as Common Packet #14 Payload | |
| Ni, Nr paylaod | All fields are same as Common Packet #14 Payload | |
| TSi Payload | All fields are same as Common Packet #14 Payload | |
| TSr Payload | All fields are same as Common Packet #14 Payload | |

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 1 and the invalid payload's critical flag is not set.
11. Observe the messages transmitted on Link A.
12. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
13. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 (BASIC)*

14. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an IKE_SA_INIT response to the NUT.
17. Observe the messages transmitted on Link A.
18. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
19. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
20. Observe the messages transmitted on Link A.
21. Repeat Steps 19 and 20 until lifetime of SA is expired.
22. Observe the messages transmitted on Link A.
23. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 32 and the invalid payload's critical flag is not set.
24. Observe the messages transmitted on Link A.
25. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
26. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 (BASIC)*

27. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
28. Observe the messages transmitted on Link A.
29. TN1 responds with an IKE_SA_INIT response to the NUT.
30. Observe the messages transmitted on Link A.
31. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
32. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
33. Observe the messages transmitted on Link A.
34. Repeat Steps 32 and 33 until lifetime of SA is expired.
35. Observe the messages transmitted on Link A.
36. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 49 and the invalid

payload's critical flag is not set.
37. Observe the messages transmitted on Link A.
38. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
39. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 (BASIC)*

40. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
41. Observe the messages transmitted on Link A.
42. TN1 responds with an IKE_SA_INIT response to the NUT.
43. Observe the messages transmitted on Link A.
44. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
45. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
46. Observe the messages transmitted on Link A.
47. Repeat Steps 45 and 46 until lifetime of SA is expired.
48. Observe the messages transmitted on Link A.
49. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 255 and the invalid payload's critical flag is not set.
50. Observe the messages transmitted on Link A.
51. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
52. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part B*

**Step 15: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 17: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 20 Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 24: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 26: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part C*

**Step 28: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 30: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 33 Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 37: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 39: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part D*

**Step 41: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 43: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 46 Judgment #3**

The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 50: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 52: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.4.2: Unrecognized payload types and Critical bit is set

**Purpose:**

To verify an IKEv2 device rejects the messages with invalid payload types when the invalid type payload's critical bit is set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                      ---
    |<---------------| IPsec {Echo Request}  |
    |                | (Packet #3)           |
    |--------------->| IPsec {Echo Reply}    | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)         |
    |                |                      ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {P, N+, SA, Nr, TSi, TSr})
    |                | (Packet #4)
    |                |
    |<---------------| IPsec {Echo Request} (new CHILD_SA)
    |                | (Packet #5)
    |-------X        | IPsec {Echo Reply} (new CHILD_SA)
    |                | (Judgment #5)
    |                |
    V                V

P: Payload with an invalid payload type
N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |
| Packet #5 | See Common Pakcet #19 |

Packet #4: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #14 Payload | |
| UDP Header | All fields are same as Common Packet #14 Payload | |
| IKEv2 Header | All fields are same as Common Packet #14 Payload | |
| E payload | Next Payload | *Invalid payload type value* |
| | Other fields are same as Common Packet #14 | |
| Invalid Payload | Next Payoad | 41 (N) |
| | Critical | 1 |
| | Reserved | 0 |
| | Payload Length | 4 |
| N Payload | All fields are same as Common Packet #14 Payload | |
| SA Payload | All fields are same as Common Packet #14 Payload | |
| Ni, Nr paylaod | All fields are same as Common Packet #14 Payload | |
| TSi Payload | All fields are same as Common Packet #14 Payload | |
| TSr Payload | All fields are same as Common Packet #14 Payload | |

*Part A: Invalid payload type 1 and Critical bit is set (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 1 and the invalid payload's critical flag is set.
11. Observe the messages transmitted on Link A.
12. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
13. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 and Critical bit is set (BASIC)*

14. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an IKE_SA_INIT response to the NUT.
17. Observe the messages transmitted on Link A.
18. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
19. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
20. Observe the messages transmitted on Link A.
21. Repeat Steps 19 and 20 until lifetime of SA is expired.
22. Observe the messages transmitted on Link A.
23. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 32 and the invalid payload's critical flag is set.
24. Observe the messages transmitted on Link A.
25. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
26. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 and Critical bit is set (BASIC)*

27. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
28. Observe the messages transmitted on Link A.
29. TN1 responds with an IKE_SA_INIT response to the NUT.
30. Observe the messages transmitted on Link A.
31. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
32. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
33. Observe the messages transmitted on Link A.
34. Repeat Steps 32 and 33 until lifetime of SA is expired.
35. Observe the messages transmitted on Link A.
36. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 49 and the invalid

payload’s critical flag is set.
37. Observe the messages transmitted on Link A.
38. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
39. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 and Critical bit is set (BASIC)*

40. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
41. Observe the messages transmitted on Link A.
42. TN1 responds with an IKE_SA_INIT response to the NUT.
43. Observe the messages transmitted on Link A.
44. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
45. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
46. Observe the messages transmitted on Link A.
47. Repeat Steps 45 and 46 until lifetime of SA is expired.
48. Observe the messages transmitted on Link A.
49. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload’s IKE Header Next Payload field is set to 255 and the invalid payload’s critical flag is set.
50. Observe the messages transmitted on Link A.
51. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to NUT.
52. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA’s SPI value in the SPI field.

**Step 13: Judgment #5**
The NUT never transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part B*

**Step 15: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 17: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 20: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 24: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 26: Judgment #5**
The NUT never transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part C*

**Step 28: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 30: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 33: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 37: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 39: Judgment #5**
The NUT never transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

*Part D*

**Step 41: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 43: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 46: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 50: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 52: Judgment #5**
The NUT never transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- None.

## Group 1.5. Cookies

### Test IKEv2.EN.I.1.1.5.1: Retrying IKE_SA_INIT request with a Notify payload of type COOKIE

**Purpose:**

To verify an IKEv2 device retries IKE_SA_INIT request using a Notify payload of type COOKIE.

**References:**

- [RFC 4306] - Sections 2.6 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                 TN1
 (End-Node)          (End-Node)
     |                    |
     |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                    | (Judgment #1)
     |<------------------| IKE_SA_INIT response (HDR, N(COOKIE))
     |                    | (Packet #1)
     |                    |
     |------------------>| IKE_SA_INIT request (HDR, N(COOKIE), SAi1, KEi, Ni)
     |                    | (Judgment #2)
     |                    |
     V                    V
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | | All fields are same as Common Packet #2 |
| UDP Header | | All fields are same as Common Packet #2 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | 0 |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 34 (IKE_SA_INIT) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |

| | | |
|---|---|---|
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_SA_INIT request including a Notify payload of type COOKIE containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 21 Notify Payload Format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A SPI Size field is set to zero.
- A Notify Message Type field is set to COOKIE (16390).
- A Notification Data field is set to the TN1 supplied cookie data.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.5.2: Interaction of COOKIE and INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles a series of the Initial Exchanges using a Notify ayload of type COOKIE and type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.6, 2.7 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

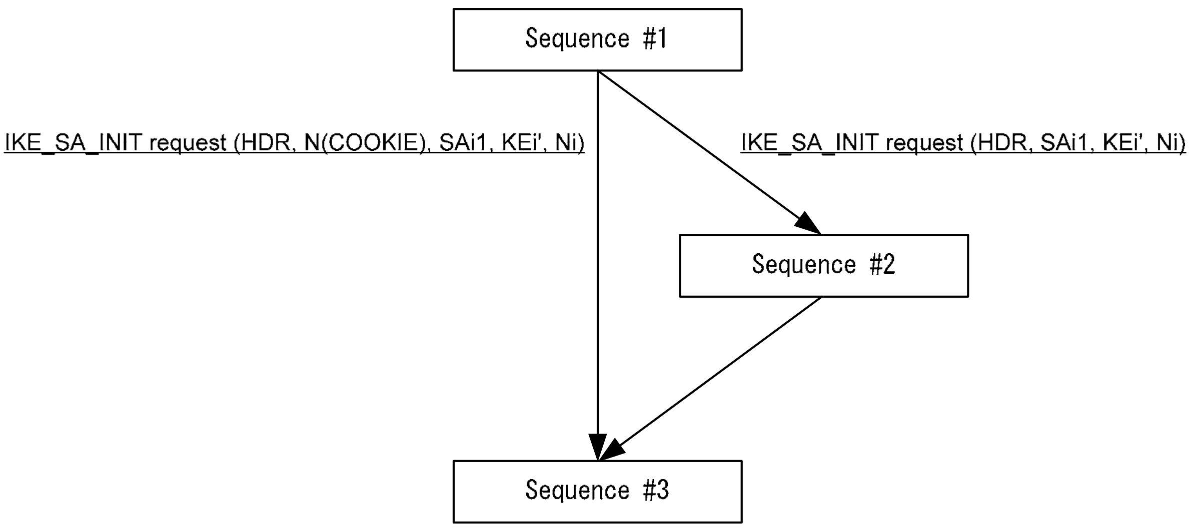
**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, configure the IKE_SA parameters as described as following. KEi payload must carry either D-H Group 14 public key value or D-H Group 24 public key value.

| | IKE_SA Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2, Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**



```
Sequence #1:
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, N(COOKIE))
    |                | (Packet #1)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi(DH#14), Ni)
    |                | (Judgment #2)
    |<---------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
    |                | (Packet #2)
    |                |
    |------*1------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                |   or
    |------*2------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                | (Judgment #3)
    |                |
    *1) If the NUT send IKE_SA_INIT request (HDR, SAi1, KEi', Ni), go to Sequence #2.
    *2) If the NUT send IKE_SA_INIT request (HDR, N(COOKIE), SAi1, KEi', Ni), go to Sequence #3.
    Otherwise, this test is failed.

Sequence #2:
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT response (HDR, N(COOKIE'))
    |                | (Packet #3)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, N(COOKIE'), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                | (Judgment #4)
    |                |
    Go to Sequence #3.

Sequence #3:
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT response (HDR, SAr1(DH#2), KEr(DH#2), Nr)
    |                | (Packet #4)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #5)
    |                |
    V                V

N: USE_TRANSPORT_MODE
It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #2 |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as the common packet #1 |
| UDP Header | | Same as the common packet #1 |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

Packet #2: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

Packet #3: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Different cookie value from Packet #1's cookie value. |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD to the NUT.
6. Observe the messages transmitted on Link A.
7. If the IKE_SA_INIT request from NUT includes a Notify payload of type COOKIE, TN1 responds with an IKE_SA_INIT response. The message has a different cookie value from the cookie value at Step3.
   A) Observe the messages transmitted on Link A.
   B) TN1 responds with an IKE_SA_INIT response.
8. If the IKE_SA_INIT request from NUT does not include a Notify payload of type COOKIE, TN1 responds with an IKE_SA_INIT response.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload has D-H Group 14 public key value. Depending on configuration, it is possible to use D-H Group 24 for SA proposal and KEi payload instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request.  The message has a Notify payload of type COOKIE with the cookie data supplied by the responder as the first payload. All other payloads are unchanged.

**Step 6: Judgment #3**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value.  The message can have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 5.  All other payloads are unchanged.

**Step 7A: Judgment #4**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value.  The message must have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 7.  All other payloads are unchanged.

**Step 9: Judgment #5**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.5.3: Interaction of COOKIE and INVALID_KE_PAYLOAD with unoptimized Responder

**Purpose:**

To verify an IKEv2 device properly handles a series of the Initial Exchanges using a Notify ayload of type COOKIE and type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.6, 2.7 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, configure the IKE_SA parameters as described as following. KEi payload must carry either D-H Group 14 public key value or D-H Group 24 public key value.

| | **IKE_SA Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2, Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                TN1
(End-Node)         (End-Node)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
     |                  | (Judgment #1)
     |<-----------------| IKE_SA_INIT response (HDR, N(COOKIE))
     |                  | (Packet #1)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), Kei(DH#14), Ni)
     |                  | (Judgment #2)
     |<-----------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
     |                  | (Packet #2)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), Kei'(DH#2), Ni)
     |                  |   or
     |----------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), Kei'(DH#2), Ni)
     |                  | (Judgment #3)
     |                  |
     |<-----------------| IKE_SA_INIT response (HDR, N(COOKIE'))
     |                  | (Packet #3)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, N(COOKIE'), SAi1(DH#2, DH#14), Kei'(DH#2), Ni)
     |                  | (Judgment #4)
     |<-----------------| IKE_SA_INIT response (HDR, SAr1(DH#2), Ker(DH#2), Nr)
     |                  | (Packet #4)
     |                  |
     |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                  | (Judgment #5)
     |                  |
     V                  V

N: USE_TRANSPORT_MODE
It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #2 |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

Packet #2: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

Packet #3: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Different cookie value from Packet #1's cookie value. |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD to the NUT.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response. The message has a different cookie value from the cookie value at Step3.
8. Observe the messages transmitted on Link A.
9. TN1 responds with an IKE_SA_INIT response.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload has D-H Group 14 public key value. Depending on configuration, it is possible to use D-H Group 24 for SA proposal and KEi payload instead of D-H Group 14.

**Step 4: Judgment #2**

The NUT transmits an IKE_SA_INIT request. The message has a Notify payload of type COOKIE with the cookie data supplied by the responder as the first payload. All other payloads are unchanged.

**Step 6: Judgment #3**

The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. The message can have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 5.

**Step 8: Judgment #4**

The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value.  The message must have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 7.  All other payloads are unchanged.

**Step 10: Judgment #5**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

# Group 1.6. Cryptographic Algorithm Negotiation

## Test IKEv2.EN.I.1.1.6.1: Cryptographic Algorithm Negotiation for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part H, configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ***ENCR_AES_CBC*** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | DELETED | DELETED | DELETED | DELETED |
| **Part C** | ENCR_3DES | ***PRF_AES128_CBC*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_AES_XCBC_96*** | Group 2 |
| **Part E** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 14*** |
| **Part F** | ENCR_3DES | ***PRF_HMAC_SHA2_256*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part G** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_HMAC_SHA2_256_128*** | Group 2 |
| **Part H** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 24*** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

This test case was deleted at revision 1.1.0.

*Part C: PRF PRF_AES128_CBC (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: D-H Group Group 14 (ADVANCED)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: PRF PRF_HMAC_SHA2_256 (ADVANCED)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link A.

*Part H: D-H Group Group 24 (ADVANCED)*

29. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
30. Observe the messages transmitted on Link A.
31. TN1 responds with an IKE_SA_INIT response to the NUT.
32. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 1.

*Part B*

This test case was deleted at revision 1.1.0.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 9.

*Part D*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_AES_XCBC_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 13.

*Part E*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as proposed algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 17.

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA2_256", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 21.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA2_256_128" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 25.

*Part H*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 24" as proposed algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 29.

**Possible Problems:**

- None.

# Test IKEv2.EN.I.1.1.6.2: Cryptographic Algorithm Negotiation for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part G, configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_AUTH exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **Extended Sequence Numbers** |
| **Part A** | ***ENCR_AES_CBC*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part B** | ***ENCR_AES_CTR*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part C** | ***ENCR_NULL*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part D** | ENCR_3DES | ***AUTH_AES_XCBC_96*** | No Extended Sequence Numbers |
| **Part E** | ENCR_3DES | ***NONE*** | No Extended Sequence Numbers |
| **Part F** | ENCR_3DES | AUTH_HMAC_SHA1_96 | ***Extended Sequence Numbers*** |
| **Part G** | ENCR_3DES | ***AUTH_HMAC_SHA2_256_128*** | No Extended Sequence Numbers |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #2 |
|---|---|

| | |
|---|---|
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

8. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
9. Observe the messages transmitted on Link A.
10. TN1 responds with an IKE_SA_INIT response to the NUT.
11. Observe the messages transmitted on Link A.
12. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
13. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
14. Observe the messages transmitted on Link A.

*Part C: Encryption Algorithm ENCR_NULL (ADVANCED)*

15. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
16. Observe the messages transmitted on Link A.
17. TN1 responds with an IKE_SA_INIT response to the NUT.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
20. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
21. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

22. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
23. Observe the messages transmitted on Link A.
24. TN1 responds with an IKE_SA_INIT response to the NUT.
25. Observe the messages transmitted on Link A.
26. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
27. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
28. Observe the messages transmitted on Link A.

*Part E: Integrity Algorithm NONE (ADVANCED)*

29. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
30. Observe the messages transmitted on Link A.
31. TN1 responds with an IKE_SA_INIT response to the NUT.
32. Observe the messages transmitted on Link A.
33. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
34. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
35. Observe the messages transmitted on Link A.

*Part F: Extended Sequence Numbers (ADVANCED)*

36. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
37. Observe the messages transmitted on Link A.
38. TN1 responds with an IKE_SA_INIT response to the NUT.
39. Observe the messages transmitted on Link A.
40. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
41. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
42. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

43. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
44. Observe the messages transmitted on Link A.
45. TN1 responds with an IKE_SA_INIT response to the NUT.
46. Observe the messages transmitted on Link A.
47. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
48. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
49. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 9: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 11: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_AES_CTR", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 14: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part C*

**Step 16: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 18: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_NULL", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 21: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part D*

**Step 23: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 25: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 28: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part E*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "NONE" and "No Extended Sequence Numbers" as proposed algorithms. However, the transform indicating "NONE" can be omitted.

**Step 35: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part F*

**Step 37: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 39: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1" and "Extended Sequence Numbers" as proposed algorithms.

**Step 42: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part G*

**Step 44: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 46: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA2_256_128" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 49: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.3: Sending Multiple Transforms for IKE_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_SA_INIT request with multiple transforms for IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_HMAC_SHA1**<br>**PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2,**<br>**Group 14 or**<br>**Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                TN1
(End-Node)        (End-Node)
    |                 |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    V                 V
```

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (ADVANCED)*

3. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.

6. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (ADVANCED)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "PRF_AES128_CBC"AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as accepted algorithms. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.4: Sending Multiple Proposals for IKE_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple proposals for CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | IKE_SA_INIT exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | Proposal #1 | IKE | ENCR_ 3DES | PRF_ HMAC_SHA1 | AUTH_ HMAC_SHA1_96 | Group 2 |
| | **Proposal #2** | **IKE** | **ENCR_ AES_CBC** | **PRF_ AES128_CBC** | **AUTH_ AES_XCBC_96** | **Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                 TN1
(End-Node)          (End-Node)
    |                    |
    |--------------->|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                    |  (Judgment #1)
    |                    |
    V                    V

N: USE_TRANSPORT_MODE
```

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request with 2 SA Proposals.
SA Proposal #1 (ESP) includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2".

SA Proposal #2 (ESP) includes "ENCR_AES_CBC", "PRF_AES128_CBC", "AUTH_AES_XCBC_96" and "D-H Group 14". Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.5: Sending Multiple Transforms for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple transforms for CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | IKE_AUTH exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
2. Observe the messages transmitted on Link A.
3. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.

4. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
6. Observe the messages transmitted on Link A.
7. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.
8. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
10. Observe the messages transmitted on Link A.
11. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "Extended Sequence Number" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.6: Sending Multiple Proposals for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple proposals for CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | IKE_AUTH exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| | **Proposal #2** | **ESP** | **ENCR_AES_CBC** | **AUTH_AES_XCBC_96** | **ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" in SA Proposal #1 (ESP) and then "ENCR_AES_CBC", "AUTH_AES_XCBC_96" and "Extended Sequence Numbers" in SA Proposal #2 (ESP) as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.7: Receipt of INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA response with a Notify payload of type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration with enabling PFS by proposing D-H Group 2 and D-H Group 14 when rekeying. KEi payload must carry D-H Group 14 public key value in CREATE_CHILD_SA request. It is possible to use D-H Group 24 instead of D-H Group 14.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                          ---
    |<---------------| IPsec {Echo Request}      |
    |                | (Packet #3)               |
    |--------------->| IPsec {Echo Reply}        | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)             |
    |                |                          ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA(DH#2, DH#14), Ni, KEi(DH#14), TSi, TSr})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {N(INVALID_KE_PAYLOAD(DH#2))})
    |                | (Packet #4)
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA(DH#2, DH#14), Ni, KEi'(DH#2), TSi, TSr})
    |                | (Judgment #5)
    |                |
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
It is possible to use DH#14 instead of DH#24.
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |

Packet #4: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #14 |
| UDP Header | | Same as Common Packet #14 |
| IKEv2 Header | | Same as Common Packet #14 |
| E Payload | | Same as Common Packet #14 |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH

response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response with a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT.
11. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers", " D-H Group 2" and " D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers", " D-H Group 2" and " D-H Group 14" as proposed algorithms and a Key Exchange payload which contains "D-H Group 2" public key value.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.8: Receipt of NO_PROPOSAL_CHOSEN

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.1.6.9: Response with inconsistent SA proposal for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles a response with a SA payload which is inconsistent with one of its proposals.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT               TN1
(End-Node)       (End-Node)
    |                |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |-------X        | IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #2 |
| UDP Header | Same as the Common Packet #2 |
| IKEv2 Header | Same as the Common Packet #2 |
| SA Payload | See below |
| KEi Payload | Same as the Common Packet #2 |
| Ni Payload | Same as the Common Packet #2 |

| | | | | |
|---|---|---|---|---|
| SA Payload | Next Payload | | | 34 (KE) |
| | Critical | | | 0 |
| | Reserved | | | 0 |
| | Payload Length | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Proposal Length | 40 |
| | | | Proposal # | 1 |
| | | | Protocol ID | 1 (IKE) |

| | | | | | |
|---|---|---|---|---|---|
| | | | SPI Size | | 0 |
| | | | # of Transforms | | 4 |
| | | | SA Transform | | See below |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 2 (PRF) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 12 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT. But the response includes a SA payload which has a different Transform ID from the proposed one.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT never transmits an IKE_AUTH request.

**Possible Problems:**

- Step 4
  The NUT may transmit or retransmit an IKE_SA_INIT request.

## Test IKEv2.EN.I.1.1.6.10: Response with inconsistent proposal for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles a response with a SA payload which is inconsistent with one of its proposals.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT               TN1
 (End-Node)       (End-Node)
     |                |
     |-------------->|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                |  (Judgment #1)
     |<--------------|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                |  (Packet #1)
     |                |
     |-------------->|  IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                |  (Judgment #2)
     |<--------------|  IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                |  (Packet #2)
     |                |
     |<--------------|  IPsec {Echo Request}
     |                |  (Packet #3)
     |-------X        |  IPsec {Echo Reply}
     |                |  (Judgment #3)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #4 |
| UDP Header | Same as the Common Packet #4 |
| IKEv2 Header | Same as the Common Packet #4 |
| E Payload | Same as the Common Packet #4 |
| IDr Payload | Same as the Common Packet #4 |
| AUTH Payload | Same as the Common Packet #4 |

| | |
|---|---|
| N Payload | Same as the Common Packet #4 |
| SA Payload | See below |
| TSi Payload | Same as the Common Packet #4 |
| TSr Payload | Same as the Common Packet #4 |

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SA Transform | | See below |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (Extended Sequence Number) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No Extended Sequence Number) |

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 12 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_AUTH response to the NUT. But the response includes a SA payload which has a different Transform ID from the proposed one.
6. TN1 transmits an Echo Request with IPsec ESP using ENCR_AES_CBC and AUTH_HMAC_SHA1_96.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT never transmits an Echo Reply with IPsec ESP using ENCR_AES_CBC and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Step 7
  The NUT may transmit or retransmit an IKE_AUTH request. And the NUT may notify INVALID_SPI.

## Test IKEv2.EN.I.1.1.6.11: Receipt of INVALID_KE_PAYLOAD in Initial Exchange

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT response with a Notify payload of type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, configure the IKE_SA parameters as described as following. KEi payload must carry D-H Group 14 public key value. It is possible to use D-H Group 24 instead of D-H Group 14.

| | **IKE_SA Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2,<br>Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |-------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
    |                | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
    |                | (Packet #1)
    |                |
    |-------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                | (Judgment #2)
    |                |
    V                V

It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #2 |
| UDP Header | | Same as Common Packet #2 |
| IKEv2 Header | | Same as Common Packet #2 |
| | IKE_SA Responder's SPI | See each Part |
| N Payload | Next Payload | 0 (No Next Payload) |

| | | |
|---|---|---|
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

*Part A: IKE_SA Responder's SPI is zero (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT. The message's IKE_SA Responder's SPI is set to zero.
4. Observe the messages transmitted on Link A.

*Part B: IKE_SA Responder's SPI is not zero (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT. The message's IKE_SA Responder's SPI is set to one.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. All other payloads are unchanged.

*Part B*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. All other payloads are unchanged.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.6.12: Creating an IKE_SA without a CHILD_SA

**Purpose:**

To verify an IKEv2 device can handles a failure of creating a CHILD_SA during the IKE_AUTH exchange.

**References:**

- [RFC 4718] - Sections 4.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N(NO_PROPOSAL_CHOSEN)})
    |                | (Packet #2)
    |                |
    |<--------------| INFORMATIONAL request (HDR, SK {})
    |                | (Packet #3)
    |-------------->| INFORMATIONAL response (HDR, SK {})
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #17 |

Packet #4: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #4 |
| UDP Header | | Same as Common Packet #4 |
| IKEv2 Header | | Same as Common Packet #4 |
| E Payload | | Same as Common Packet #4 |
| IDr Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | NO_PROPOSAL_CHOSEN (14) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of type NO_PROPOSAL_CHOSEN to the NUT.
6. TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

## Group 1.7. Traffic Selector Negotiation

### Test IKEv2.EN.I.1.1.7.1: Narrowing the range of members of the set of traffic selectors

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.9

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |<---------------| IPsec {TCP SYN}
    |                | (Packet #3)
    |--------------->| IPsec {TCP RST}
    |                | (Judgment #3)
    |                |
    |<---------------| IPsec {ICMPv6 Echo Request}
    |                | (Packet #4)
    |-------X        | IPsec {ICMPv6 Echo Reply}
    |                | (Judgment #4)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |

| | |
|---|---|
| Packet #3 | See below |
| Packet #4 | See Common Packet #19 |

Packet #2: IKE_AUTH response

| | | | |
|---|---|---|---|
| TSi Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (tcp) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | | | |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (tcp) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

Packet #3: TCP-SYN

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The cryptographic checksum of the entire message |
| TCP Header | Source Port | 500 |
| | Destination Port | 500 |
| | Flags | SYN (0x02) |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT.
6. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port on NUT.
7. Observe the messages transmitted on Link A.
8. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT never transmit an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

# Group 1.8. Error Handling

## Test IKEv2.EN.I.1.1.8.1: INVALID_IKE_SPI

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.1.8.2: INVALID_SELECTORS

This test case was deleted at revision 1.1.0.

# Group 1.10 Authentication of the IKE_SA

## Test IKEv2.EN.I.1.1.10.1: Sending CERT Payload

**Purpose:**

To verify an IKEv2 device handles CERTREQ payload and transmits CERT payload properly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Local | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | NUT's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | nut.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | nut@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, CERT, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #2 |
| UDP Header | Same as the Common Packet #2 |
| IKEv2 Header | Same as the Common Packet #2 |
| SA Payload | Same as the Common Packet #2 |

| | | |
|---|---|---|
| KE Payload | Same as the Common Packet #2 | |
| Nr Payload | Next Payload | 38 (CERTREQ) |
| | Other fields are same as the Common Packet #2 | |
| CERTREQ Payload | See below | |

| | | |
|---|---|---|
| CERTREQ Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Authority | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT request from the NUT, TN1 responds with an IKE_SA_INIT response with a CERTREQ payload to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT request from the NUT, TN1 responds with an IKE_SA_INIT response with a CERTREQ payload to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT request from the NUT, TN1 responds with an IKE_SA_INIT response with a CERTREQ payload to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_IPV6_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**

The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_FQDN and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_RFC822_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.10.2: Sending CERTREQ Payload

**Purpose:**

To verify an IKEv2 device transmits CERTREQ payload and handles CERT payload properly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
 (End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH, N, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

7. TN1 responds with an IKE_SA_INIT response to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.10.3: RSA Digital Signature

**Purpose:**

To verify an IKEv2 device authenticates the corresponding node by RSA Digital Signature.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT               TN1
(End-Node)       (End-Node)
    |                 |
    |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |---------------->| IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH, N, SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |<----------------| IKE_AUTH response (HDR, SK {IDr, CERT, AUTH, N, SAr2, TSi, TSr})
    |                 | (Packet #2)
    |                 |
    |<----------------| IPsec {Echo Request}
    |                 | (Packet #3)
    |---------------->| IPsec {Echo Reply}
    |                 | (Judgment #3)
    |                 |
    V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #4 | |
| UDP Header | Same as Common Packet #4 | |
| IKEv2 Header | Same as Common Packet #4 | |
| E Payload | Same as Common Packet #4 | |
| IDr Payload | Next Payload | 37 (CERT) |
| | Other fields are same as the Common Packet #4 | |
| CERT Payload | See below | |
| AUTH Payload | Same as Common Packet #4 | |
| N Payload | Same as Common Packet #4 | |
| SA Payload | Same as Common Packet #4 | |
| TSi Payload | Same as Common Packet #4 | |
| TSr Payload | Same as Common Packet #4 | |

| | | |
|---|---|---|
| CERT Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Data | TN1's X.509 Certificate |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

8. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
9. Observe the messages transmitted on Link A.
10. TN1 responds with an IKE_SA_INIT response to the NUT.
11. Observe the messages transmitted on Link A.
12. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
13. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
14. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

15. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
16. Observe the messages transmitted on Link A.
17. TN1 responds with an IKE_SA_INIT response to the NUT.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
20. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
21. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part B*

**Step 9: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 11: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 14: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part C*

**Step 16: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 18: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 21: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.10.4: HEX string PSK

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 2.15

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | Authentication Key Value |
|---|---|
| **Remote** | 0xabadcafeabadcafeabadcafeabadcafe (128 bit binary string) |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Group 1.11. Invalid values

### Test IKEv2.EN.I.1.1.11.1: Non zero RESERVED fields in IKE_SA_INIT response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response whose RESERVED fields are set to one to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.11.2: Non zero RESERVED fields in IKE_AUTH response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4<br>All RESERVED fields are set to one. |
| Packet #3 | See Common Packet #19 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response whose RESERVED fields are set to one to the NUT

6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

### Test IKEv2.EN.I.1.1.11.3: Version bit is set

**Purpose:**

To verify an IKEv2 device ignores the content of Version bit in IKE messages.

**References:**

- [RFC 4306] - Sections 3.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                TN1
(End-Node)        (End-Node)
     |                 |
     |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |                 |
     V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2<br>Version bit is set to one. |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response whose Version bit is set to one to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.11.4: Unrecognized Notify Message Type of Error

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type intended for reporting error.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr, N+})
    |                | (Packet #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |-------X        | no IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
N+: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH response

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #4 |
| UDP Header | All fields are same as Common Packet #4 |
| IKEv2 Header | All fields are same as Common Packet #4 |
| E Payload | All fields are same as Common Packet #4 |
| IDr Payload | All fields are same as Common Packet #4 |

| | | |
|---|---|---|
| AUTH Payload | All fields are same as Common Packet #4 | |
| N Payload | All fields are same as Common Packet #4 | |
| SA Payload | All fields are same as Common Packet #4 | |
| TSi Payload | All fields are same as Common Packet #4 | |
| TSr paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #4 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16383 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of unrecognized Notify Message Type value.
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT never transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.1.11.5: Unrecognized Notify Message Type of Status

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type intended for reporting status.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr, N+})
    |                | (Packet #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
N+: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #4 |
| UDP Header | All fields are same as Common Packet #4 |
| IKEv2 Header | All fields are same as Common Packet #4 |
| E Payload | All fields are same as Common Packet #4 |
| IDr Payload | All fields are same as Common Packet #4 |

| | | |
|---|---|---|
| AUTH Payload | All fields are same as Common Packet #4 | |
| N Payload | All fields are same as Common Packet #4 | |
| SA Payload | All fields are same as Common Packet #4 | |
| TSi Payload | All fields are same as Common Packet #4 | |
| TSr paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #4 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 65535 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of unrecognized Notify Message Type value.
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

# Group 2. The CREATE_CHILD_SA Exchange

## Group 2.1. Header and Payload Formats

### Test IKEv2.EN.I.1.2.1.1: Sending CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device transmits CREATE_CHILD_SA request using properly Header and Payloads format.

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                           ---
    |<---------------| IPsec {Echo Request}       |
    |                | (Packet #3)                |
    |--------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)              |
    |                |                           ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |                |
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired for 30 seconds.
9. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

10. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an IKE_SA_INIT response to the NUT.
13. Observe the messages transmitted on Link A.
14. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
15. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
16. Observe the messages transmitted on Link A.
17. Repeat Steps 15 and 16 until lifetime of SA is expired for 30 seconds.
18. Observe the messages transmitted on Link A.

*Part C: Notify Payload (REKEY_SA) Format (BASIC)*

19. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. TN1 responds with an IKE_SA_INIT response to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
24. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
25. Observe the messages transmitted on Link A.
26. Repeat Steps 24 and 25 until lifetime of SA is expired for 30 seconds.
27. Observe the messages transmitted on Link A.

*Part D: Notify Payload (USE_TRANSPORT_MODE) Format (BASIC)*

28. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
29. Observe the messages transmitted on Link A.
30. TN1 responds with an IKE_SA_INIT response to the NUT.
31. Observe the messages transmitted on Link A.
32. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
33. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
34. Observe the messages transmitted on Link A.
35. Repeat Steps 33 and 34 until lifetime of SA is expired for 30 seconds.
36. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (BASIC)*

37. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
38. Observe the messages transmitted on Link A.
39. TN1 responds with an IKE_SA_INIT response to the NUT.
40. Observe the messages transmitted on Link A.
41. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
42. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
43. Observe the messages transmitted on Link A.
44. Repeat Steps 42 and 43 until lifetime of SA is expired for 30 seconds.
45. Observe the messages transmitted on Link A.

*Part F: Nonce Payload Format (BASIC)*

46. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
47. Observe the messages transmitted on Link A.
48. TN1 responds with an IKE_SA_INIT response to the NUT.
49. Observe the messages transmitted on Link A.
50. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
51. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
52. Observe the messages transmitted on Link A.
53. Repeat Steps 51 and 52 until lifetime of SA is expired for 30 seconds.
54. Observe the messages transmitted on Link A.

*Part G: TSi Payload Format (BASIC)*

55. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
56. Observe the messages transmitted on Link A.
57. TN1 responds with an IKE_SA_INIT response to the NUT.
58. Observe the messages transmitted on Link A.

59. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
60. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
61. Observe the messages transmitted on Link A.
62. Repeat Steps 60 and 61 until lifetime of SA is expired for 30 seconds.
63. Observe the messages transmitted on Link A.

*Part H: TSr Payload Format (BASIC)*

64. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
65. Observe the messages transmitted on Link A.
66. TN1 responds with an IKE_SA_INIT response to the NUT.
67. Observe the messages transmitted on Link A.
68. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
69. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
70. Observe the messages transmitted on Link A.
71. Repeat Steps 69 and 70 until lifetime of SA is expired for 30 seconds.
72. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 22 Header format**

- An IKE_SA Initiator's SPI field is set to same as the IKE_SA_INIT request's IKE_SA Initiator's SPI field value.
- An IKE_SA Responder's SPI field is set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field is set to Encrypted Payload (46).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to CREATE_CHILD_SA (36).
- A Flags field is set to (00010000)2 = (16)10.
- A Message ID field is set to the value incremented the previous IKE message's Message ID by one.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 11: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 13: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 16: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 18: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 23 Encrypted payload**

- A Next Payload field is set to N Payload (41).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.

- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 22: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 25: Judgment #3**

The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 27: Judgment #4**

The NUT transmits a CREATE_CHILD_SA request including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 24 Notify Payload format**

- A Next Payload field is set to N Payload (41).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 12 bytes for this REKEY_SA.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to the size of CHILD_SA Inbound SPI value to be rekeyed. It is 4 bytes for ESP.

- A Notify Message Type field is set to REKEY_SA (16393).
- A Security Parameter Index field is set to SPI value to be rekeyed.
- A Notification Data field is empty.

*Part D*

**Step 29: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 31: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 34: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 36: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 25 Notify Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 8 bytes for USE_TRANSPORT_MODE.
- A Protocol ID field is set to undefined (0).
- A SPI Size field is set to zero.
- A Notify Message Type field is set to USE_TRANSPORT_MODE (16391)

*Part E*

**Step 38: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 40: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 43: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 45: Judgment #4**

```
                            1                   2                   3
           0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
          ! Next     44   !0!       0       ! Length           40          !             |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---         |
          !       0       !        0        ! Length           36          !  |          |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          ! Number    1   ! Prot ID    3    ! SPI Size   4    ! Trans Cnt  3 !  |          |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          ! SPI value                                                       !  |          |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        | !       3       !        0        ! Length            8          !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |SA Payload
        | ! Type  1  (EN) !        0        ! Transform ID     3    (3DES) !  | Proposal |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        | !       3       !        0        ! Length            8          !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        | ! Type  3  (IN) !        0        ! Transform ID     2    (SHA1) !  |          |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        | !       0       !        0        ! Length            8          !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        | ! Type  5  (ESN)!        0        ! Transform ID     0      (No) !  |          |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 26 SA Payload contents**

The NUT transmits a CREATE_CHILD_SA request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 27 SA Payload format**

- A Next Payload field is set to Ni Payload (40).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 28 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field is set to 1 if this structure is the first proposal, otherwise set to 1 greater thatn the previous proposal.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to 4.
- A # of Transforms field is set to 3.
- A SPI field is set to the sending entity's SPI (4 octets value)

Transform field is set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 29 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.

- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field is set to ESN (5).
- A RESERVED field is set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 47: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 49: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 52: Judgment #3**

The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 54: Judgment #4**

The NUT transmits a CREATE_CHILD_SA request including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 30 Nonce Payload format**

- A Next Payload field is set to TSi Payload (44).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Nonce Data field is set to random data generated by the transmitting entity.
- The size of the Nonce must between 16 and 256 octets.

*Part G*

**Step 56: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 58: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 61: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 63: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 31 TSi Payload format**

- A Next Payload field is set to TSr Payload (45).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to the number of actual traffic selectors.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 32 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).

- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to NUT address.
- A Ending Address field is set to greater thatn or equal to NUT address.

*Part H*

**Step 65: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 67: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 70: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 72: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 33 TSr Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to 1.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 34 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to TN1 address.
- An Ending Address field is set to less than or equal to TN1 address.

**Possible Problems:**

- The implementation may use different SA lifetimes by the implementation policy. In that case, the tester must change the expiration time to wait CREATE_CHILD_SA request.

- CREATE_CHILD_SA request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(REKEY_SA)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, Ni, [KEi], TSi, TSr
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- Each of transforms can be located in the any order.

- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

# Group 2.2. Use of Retransmission Timers

## Test IKEv2.EN.I.1.2.2.1: Retransmissions of CREATE_CHILD_SA requests

**Purpose:**

To verify an IKEv2 device retransmits CREATE_CHILD_SA request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                 | (Packet #2)
    |                 |
   ...               ...
    |                 |                         ---
    |<----------------| IPsec {Echo Request}      |
    |                 | (Packet #3)               |
    |---------------->| IPsec {Echo Reply}        | repeat Echo exchange until lifetime of SA is expired
    |                 | (Judgment #3)             |
    |                 |                         ---
   ...               ...
    |                 |
    |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Judgment #4)
    |                 |
    |                 * wait for the event of a timeout
    |                 |
    |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Judgment #5)
    |                 |
    V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 waits for the event of a timeout on NUT.
11. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 11: Judgment #5**
The NUT retransmits a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different lifetime of SA.
- Each NUT has the different retransmission timers.

## Test IKEv2.EN.I.1.2.2.2: Stop of retransmission of CREATE_CHILD_SA requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
     |                 |
     |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                 | (Packet #2)
     |                 |
    ...               ...
     |                 |                           ---
     |<----------------| IPsec {Echo Request}       |
     |                 | (Packet #3)                |
     |---------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
     |                 | (Judgment #3)              |
     |                 |                           ---
    ...               ...
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                 | (Judgment #4)
     |                 |
     |                 * wait for the event of a timeout
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                 | (Judgment #5)
     |<----------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                 | (Packet #4)
     |                 |
     |                 * wait for the event of a timeout
     |                 |
     |--------X        | never send CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                 | (Judgment #6)
     |                 |
     V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 waits for the event of a timeout on NUT.
11. Observe the messages transmitted on Link A.

12. TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. TN1 waits for the event of a timeout on NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 11: Judgment #5**
The NUT retransmits a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Step 14: Judgment #6**
The NUT stops the retransmissions of a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different lifetime of SA.
- Each NUT has the different retransmission timers.

# Group 2.3. Rekeying CHILD_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.EN.I.1.2.3.1: Close the replaced CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |               | (Packet #2)
    |               |
   ...             ...
    |               |                          ---
    |<--------------| IPsec {Echo Request}      |
    |               | (Packet #3)               |
    |-------------->| IPsec {Echo Reply}        | repeat Echo exchange until lifetime of SA is expired
    |               | (Judgment #3)             |
    |               |                          ---
   ...             ...
    |               |
    |-------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |               | (Judgment #4)
    |<--------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |               | (Packet #4)
    |               |
    |-------------->| INFORMATIONAL request (HDR, SK {D})
    |               | (Judgment #5)
    V               V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response with a Delete payload to the NUT.
13. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to the NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Step 14: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.2: Use of the new CHILD_SA

**Purpose:**

To verify an IKEv2 device properly rekeys CHILD_SA

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                TN1
(End-Node)        (End-Node)
    |                 |
    |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                 | (Packet #2)
    |                 |
   ...               ...
    |                 |                          ---
    |<----------------| IPsec {Echo Request}        |
    |                 | (Packet #3)                 |
    |---------------->| IPsec {Echo Reply}          | repeat Echo exchange until lifetime of SA is expired
    |                 | (Judgment #3)               |
    |                 |                          ---
   ...               ...
    |                 |
    |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Judgment #4)
    |<----------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |                 | (Packet #4)
    |                 |
    |---------------->| INFORMATIONAL request (HDR, SK {D})
    |                 | (Judgment #5)
    |<----------------| INFORMATIONAL response (HDR, SK {D})
    |                 | (Packet #5)
    |                 |
    |<----------------| IPsec {Echo Request}
    |                 | (Packet #6)
    |---------------->| IPsec {Echo Reply}
    |                 | (Judgment #6)
    V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #19<br>This packet is cryptographically protected by the new CHILD_SA negotiated at Step 10. |

Packet #5: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |

| | | |
|---|---|---|
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value to be deleted |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response with a Delete payload to the NUT.
13. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to the NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Step 14: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.3: Lifetime of CHILD_SA expires

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of CHILD_SAs.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Packet #1)
    |               |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Judgment #2)
    |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Packet #2)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #3)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #3)
    |               |
    |               * wait for the event of a timeout of CHILD_SA
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #4)
    |--------X      | IPsec {Echo Reply}
    |               | (Judgment #4)
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #19 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. TN1 waits for the event of a timeout on the NUT.
9. After timeout of CHILD_SA on the NUT, TN1 transmits an Echo Request with IPsec ESP which has expired to the NUT.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #4**
The NUT does not transmit an Echo Reply with IPsec ESP using already expired CHILD_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.4: Sending Multiple Transform

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | CREATE_CHILD_SA exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)       (End-Node)
    |                 |
    |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                 | (Packet #2)
    |                 |
   ...               ...
    |                 |                      ---
    |<----------------| IPsec {Echo Request}   |
    |                 | (Packet #3)            |
    |---------------->| IPsec {Echo Reply}     | repeat Echo exchange until lifetime of SA is expired
    |                 | (Judgment #3)          |
    |                 |                      ---
   ...               ...
    |                 |
    |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Judgment #4)
    |                 |
    V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired for 30 seconds.
9. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (ADVANCED)*

10. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an IKE_SA_INIT response to the NUT.
13. Observe the messages transmitted on Link A.
14. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
15. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
16. Observe the messages transmitted on Link A.
17. Repeat Steps 15 and 16 until lifetime of SA is expired for 30 seconds.
18. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (ADVANCED)*

19. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. TN1 responds with an IKE_SA_INIT response to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
24. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
25. Observe the messages transmitted on Link A.
26. Repeat Steps 24 and 25 until lifetime of SA is expired for 30 seconds.
27. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

*Part B*

**Step 11: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 13: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 16: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 18: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

*Part C*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 25: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 27: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.5: Sending Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple proposals to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | CREATE_CHILD_SA exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| | **Proposal #2** | **ESP** | **ENCR_AES_CBC** | **AUTH_AES_XCBC_96** | **ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                        ---
    |<---------------| IPsec {Echo Request}     |
    |                | (Packet #3)              |
    |--------------->| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)            |
    |                |                        ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |                |
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired for 30 seconds.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" in SA Proposal #1 (ESP) and then "ENCR_AES_CBC", "AUTH_AES_XCBC_96" and "Extended Sequence Numbers" in SA Proposal #2 (ESP) as accepted algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.6: Rekeying Failure

**Purpose:**

To verify an IKEv2 device properly handles rekeying failure.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 30 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Judgment #1)
     |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Packet #1)
     |                |
     |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                | (Judgment #2)
     |<--------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                | (Packet #2)
     |                |
    ...              ...
     |                |                          ---
     |<--------------| IPsec {Echo Request}       |
     |                | (Packet #3)                |
     |-------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
     |                | (Judgment #3)              |
     |                |                          ---
    ...              ...
     |                |
     |-------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                | (Judgment #4)
     |<--------------| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
     |                | (Packet #4)
     |                |
     |<--------------| INFORMATIONAL request (HDR, SK { })
     |                | (Packet #5)
     |-------X        | no INFORMATIONAL response (HDR, SK { })
     |                | (Judgment #5)
     |                |
     V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14 |
| Packet #5 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying IKE_SA from the NUT, TN1 rejects the NUT's proposal. TN1 responds with a CREATE_CHILD_SA response with a Notify of type NO_PROPOSAL_CHOSEN.
11. TN1 trasnmits an INFORMATIONAL request for liveness check to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request for rekeying IKE_SA.
The request includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #5**
The NUT never responds with an INFORMATIONAL response to an INFORMATIONAL request.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.7: Perfect Forward Secrecy

**Purpose:**

To verify an IKEv2 device properly rekeys CHILD_SA when Perfect Forward Secrecy enables.

**References:**

- [RFC 4306] - Sections 2.12

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds. Enable PFS.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                            ---
    |<---------------| IPsec {Echo Request}        |
    |                | (Packet #3)                 |
    |--------------->| IPsec {Echo Reply}          | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)               |
    |                |                            ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, KEi, TSi, TSr})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, KEr, TSi, TSr})
    |                | (Packet #4)
    |                |
    |--------------->| INFORMATIONAL request (HDR, SK {D})
    |                | (Judgment #5)
    |<---------------| INFORMATIONAL response (HDR, SK {D})
    |                | (Packet #5)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #6)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #6)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |
| Packet #5 | See below |
| Packet #6 | See Common Packet #19<br>This packet is cryptographically protected by the new CHILD_SA negotiated at Step 10. |

Packet #4: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #14 | |
| UDP Header | Same as the Common Packet #14 | |
| IKEv2 Header | Same as the Common Packet #14 | |
| E Payload | Same as the Common Packet #14 | |
| N Payload | Same as the Common Packet #14 | |
| N Payload | Same as the Common Packet #14 | |
| SA Payload | Same as the Common Packet #14 | |
| Nr Payload | Next Payload | 34 (KE) |
| KEr Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |
| | Key Exchange Data | any |
| TSi Payload | Same as the Common Packet #14 | |
| TSr Payload | Same as the Common Packet #14 | |

Packet #5: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #18 | |
| UDP Header | Same as the Common Packet #18 | |
| IKEv2 Header | Same as the Common Packet #18 | |
| E Payload | Other fields are same as the Common Packet #18 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response with a Delete payload to the NUT.
13. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to the NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Step 14: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.3.8: Use of the old CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles new CHILD_SA and old CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
   ...              ...
    |                |                           ---
    |<---------------| IPsec {Echo Request}       |
    |                | (Packet #3)                |
    |--------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)              |
    |                |                           ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |                | (Packet #4)
    |                |
    |<---------------| IPsec {Echo Request} (old CHILD_SA)
    |                | (Packet #5)
    |--------------->| IPsec {Echo Reply} (old CHILD_SA or new CHILD_SA)
    |                | (Judgment #5)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14 |
| Packet #5 | See Common Packet #19<br>This packet is cryptographically protected by the new CHILD_SA negotiated at Step 5. |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms again.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 12: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP. The NUT can use both the first CHILD_SA and the new CHILD_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Group 2.4. Rekeying IKE_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.EN.I.1.2.4.1: Close the replaced IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                        ---
    |<---------------| IPsec {Echo Request}     |
    |                | (Packet #3)              |
    |--------------->| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)            |
    |                |                        ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {SA, Nr, KEr})
    |                | (Packet #4)
    |                |
    |--------------->| INFORMATIONAL request (HDR, SK {D})
    |                | (Judgment #5)
    |<---------------| INFORMATIONAL response (HDR, SK {})
    |                | (Packet #5)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #6)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #6)
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #12 |
| Packet #5 | See Common Packet #18 |
| Packet #6 | See Common Packet #19 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds

with a CREATE_CHILD_SA response to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response to close the replaced IKE_SA.
13. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 14: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.4.2: Use of the new IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
     |                |
     |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Judgment #1)
     |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Packet #1)
     |                |
     |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Judgment #2)
     |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Packet #2)
     |                |
    ...              ...
     |                |                           ---
     |<---------------| IPsec {Echo Request}       |
     |                | (Packet #3)                |
     |--------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
     |                | (Judgment #3)              |
     |                |                           ---
    ...              ...
     |                |
     |--------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                | (Judgment #4)
     |<---------------| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                | (Packet #4)
     |                |
     |--------------->| INFORMATIONAL request (HDR, SK {D})
     |                | (Judgment #5)
     |<---------------| INFORMATIONAL response (HDR, SK {})
     |                | (Packet #5)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK {})
     |                | (Packet #6)
     |--------------->| INFORMATIONAL response (HDR, SK {})
     |                | (Judgment #6)
     V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #12 |
| Packet #5 | See Common Packet #18 |
| Packet #6 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds

with a CREATE_CHILD_SA response to the NUT.

11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response to an INFORMATIONAL request to close the replaced IKE_SA.
13. TN1 transmits an INFORMATIONAL request with no payloads cryptographically protected by new IKE_SA.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 14: Judgment #6**
The NUT resopndes with an INFORMATIONAL response with not payloads cryptographically protected by new IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.4.3: Lifetime of IKE_SA expires

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)      (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {})
    |                | (Packet #3)
    |--------------->| INFORMATIONAL response (HDR, SK {})
    |                | (Judgment #3)
    |                |
    |                * wait for the event of a timeout of IKE_SA
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {})
    |                | (Packet #4)
    |--------X       | INFORMATIONAL response (HDR, SK {})
    |                | (Judgment #4)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #17 |
| Packet #4 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
7. Observe the messages transmitted on Link A.
8. TN1 waits for the event of a timeout on the NUT.
9. After timeout of CHILD_SA on the NUT, TN1 transmits an INFORMATIONAL request with no payloads using already expired IKE_SA.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT responds with an INFORMATIONAL response with no payloads.

**Step 10: Judgment #4**
The NUT does not respond with an INFORMATIONAL response with no payloads using already expired IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Test IKEv2.EN.I.1.2.4.4: Sending Multiple Transform

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple transforms to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.

| | **CREATE_CHILD_SA exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_3DES<br>ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_HMAC_SHA1<br>PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_HMAC_SHA1_96<br>AUTH_AES_XCBC_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2,<br>Group 14 or<br>Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                          ---
    |<---------------| IPsec {Echo Request}       |
    |                | (Packet #3)                |
    |--------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)              |
    |                |                          ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                | (Judgment #4)
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (ADVANCED)*

10. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an IKE_SA_INIT response to the NUT.
13. Observe the messages transmitted on Link A.
14. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
15. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
16. Observe the messages transmitted on Link A.
17. Repeat Steps 6 and 7 until lifetime of SA is expired.
18. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (ADVANCED)*

19. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. TN1 responds with an IKE_SA_INIT response to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
24. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
25. Observe the messages transmitted on Link A.
26. Repeat Steps 6 and 7 until lifetime of SA is expired.
27. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (ADVANCED)*

28. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
29. Observe the messages transmitted on Link A.
30. TN1 responds with an IKE_SA_INIT response to the NUT.
31. Observe the messages transmitted on Link A.
32. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
33. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
34. Observe the messages transmitted on Link A.
35. Repeat Steps 6 and 7 until lifetime of SA is expired.
36. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part B*

**Step 11: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 13: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 16: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 18: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part C*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 25: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 27: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part D*

**Step 29: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 31: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 34: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 36: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.
And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.4.5: Sending Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple proposal to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.

| | CREATE_CHILD_SA exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | Proposal #1 | IKE | ENCR_ 3DES | PRF_ HMAC_SHA1 | AUTH_ HMAC_SHA1_96 | Group 2 |
| | **Proposal #2** | **IKE** | **ENCR_ AES_CBC** | **PRF_ AES128_CBC** | **AUTH_ AES_XCBC_96** | **Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT               TN1
 (End-Node)        (End-Node)
     |                 |
     |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                 | (Packet #2)
     |                 |
    ...               ...
     |                 |                          ---
     |<----------------| IPsec {Echo Request}      |
     |                 | (Packet #3)               |
     |---------------->| IPsec {Echo Reply}        | repeat Echo exchange until lifetime of SA is expired
     |                 | (Judgment #3)             |
     |                 |                          ---
    ...               ...
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                 | (Judgment #4)
     V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**

The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request with 2 SA Proposals.
SA Proposal #1 (ESP) includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2".
SA Proposal #2 (ESP) includes "ENCR_AES_CBC", "PRF_AES128_CBC", "AUTH_AES_XCBC_96" and "D-H Group 14". Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.4.6: Use of the old IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles new CHILD_SA and old CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                         ---
    |<---------------| IPsec {Echo Request}     |
    |                | (Packet #3)              |
    |--------------->| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)            |
    |                |                         ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK SA, Ni})
    |                | (Judgment #4)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
    |                | (Packet #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {}) (old IKE_SA)
    |                | (Packet #5)
    |--------------->| INFORMATIONAL response (HDR, SK {}) (old IKE_SA)
    |                | (Judgment #5)
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #12 |
| Packet #5 | See Common Packet #17<br>(Use old IKE_SA) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. TN1 transmits an INFORMATIONAL request with no payload to the NUT. The message is encrypted by the old IKE_SA.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #5**
The NUT transmits an INFORMATIONAL response with no payload to the TN1. THe message is encrypted by the old IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.4.7: Changing PRFs when rekeying the IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
  Configure the devices according to the Common Configuration except for *Italic* parameters.

| | **IKE_SA Rekeying Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | ***PRF_AES128_XCBC*** | AUTH_HMAC_SHA1_96 | Group 2 |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                 TN1
(End-Node)          (End-Node)
     |                   |
     |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                   | (Judgment #1)
     |<------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                   | (Packet #1)
     |                   |
     |------------------>| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                   | (Judgment #2)
     |<------------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                   | (Packet #2)
     |                   |
    ...                 ...
     |                   |                         ---
     |<------------------| IPsec {Echo Request}     |
     |                   | (Packet #3)              |
     |------------------>| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
     |                   | (Judgment #3)            |
     |                   |                         ---
    ...                 ...
     |                   |
     |------------------>| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                   | (Judgment #4)
     |<------------------| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                   | (Packet #4)
     |                   |
     |------------------>| INFORMATIONAL request (HDR, SK {D})
     |                   | (Judgment #5)
     |<------------------| INFORMATIONAL response (HDR, SK {})
     |                   | (Packet #5)
     |                   |
     |<------------------| INFORMATIONAL request (HDR, SK {})
     |                   | (Packet #6)
     |------------------>| INFORMATIONAL response (HDR, SK {})
     |                   | (Judgment #6)
     V                   V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |
| Packet #5 | See Common Packet #18 |
| Packet #6 | See Common Packet #17 |

Packet #4: CREATE_CHILD_SA response

Packet #4 is same as Common Packet  #12 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform TypePRF replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (PRF_AES128_XCBC) |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an INFORMATIONAL response to an INFORMATIONAL request to close the replaced IKE_SA.
13. TN1 transmits an INFORMATIONAL request with no payloads cryptographically protected by new IKE_SA.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_AES128_XCBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 14: Judgment #6**
The NUT resopndes with an INFORMATIONAL response with not payloads cryptographically protected by new IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Group 2.5. Creating New CHILD_SAs with the CREATE_CHILD_SA Exchanges

## Test IKEv2.EN.I.1.2.5.1: Create new CHILD_SA by sending CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to generate new CHILD_SAs.

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3
- [RFC 4718] - Sections 4.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See Common Packet #4 |

Packet #2: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #4 | |
| UDP Header | Same as the Common Packet #4 | |
| IKEv2 Header | Same as the Common Packet #4 | |
| E Payload | Same as the Common Packet #4 | |
| IDi Payload | Same as the Common Packet #4 | |
| AUTH Payload | Same as the Common Packet #4 | |
| N Payload | Same as the Common Packet #4 | |
| SA Payload | Same as the Common Packet #4 | |
| TSi Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. NUT starts to negotiate new CHILD_SA with TN1 by sending CREATE_CHILD_SA request.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.I.1.2.5.2: Receipt of cryptographically valid message on the new SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to generate new CHILD_SAs.

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3
- [RFC 4718] - Sections 4.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
     NUT               TN1
 (End-Node)        (End-Node)
     |                 |
     |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                 | (Packet #2)
     |                 |
     |<----------------| IPsec {TCP-SYN}
     |                 | (Packet #3)
     |---------------->| IPsec {TCP-RST}
     |                 | (Judgment #3)
     |                 |
     |<----------------| IPsec {Echo Request}
     |                 | (Packet #4)
     |-------X         | IPsec {Echo Reply}
     |                 | (Judgment #4)
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
     |                 | (Judgment #5)
     |<----------------| CREATE_CHILD_SA response (HDR, SK {N, SA, Nr, TSi, TSr})
     |                 | (Packet #5)
     |                 |
     |<----------------| IPsec {TCP-SYN}
     |                 | (Packet #6)
     |---------------->| IPsec {TCP-RST}
     |                 | (Judgment #6)
     |                 |
     |<----------------| IPsec {Echo Request}
     |                 | (Packet #7)
     |---------------->| IPsec {Echo Reply}
     |                 | (Judgment #7)
     |                 |
     V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #19 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See Common Packet #19 |

- Packet #2: IKE_AUTH response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #4 |
| UDP Header | Same as the Common Packet #4 |
| IKEv2 Header | Same as the Common Packet #4 |
| E Payload | Same as the Common Packet #4 |
| IDi Payload | Same as the Common Packet #4 |
| AUTH Payload | Same as the Common Packet #4 |
| N Payload | Same as the Common Packet #4 |
| SA Payload | Same as the Common Packet #4 |

| | | |
|---|---|---|
| TSi Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

- Packet #3: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| TCP Header | Source Port | 30000 |
| | Destination Port | 30000 |
| | Flags | SYN (0x02) |

- Packet #5: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #8 | |
| UDP Header | Same as the Common Packet #8 | |
| IKEv2 Header | Same as the Common Packet #8 | |
| E Payload | Same as the Common Packet #8 | |
| IDi Payload | Same as the Common Packet #8 | |
| AUTH Payload | Same as the Common Packet #8 | |
| N Payload | Same as the Common Packet #8 | |
| SA Payload | Same as the Common Packet #8 | |
| TSi Payload | Other fields are same as the Common Packet #8 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #8 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link X |
| | | Ending Address | NUT's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |

| | | | |
|---|---|---|---|
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link A |
| | | Ending Address | TN1's Global Address on Link A |

- Packet #6: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| TCP Header | Source Port | 30000 |
| | Destination Port | 30000 |
| | Flags | SYN (0x02) |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT.
6. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port 30000 on NUT.
7. Observe the messages transmitted on Link A.
8. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
9. Observe the messages transmitted on Link A.
10. NUT starts to negotiate new CHILD_SA with TN1 by sending CREATE_CHILD_SA request.
11. Observe the messages transmitted on Link A.
12. After a reception of CREATE_CHILD_SA request from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port 30000 on NUT.
14. Observe the messages transmitted on Link A.
15. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT never transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 14: Judgment #6**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 16: Judgment #7**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- If the NUT uses TCP port 30000 for other applications, the TN1 transmits TCP-SYN packets to other closed TCP port on the NUT.

# Group 2.6. Exchange Collisions

## Test IKEv2.EN.I.1.2.6.1: Simultaneous CHILD_SA Close

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.2: Simultaneous IKE_SA Close

This test case was deleted at revision 1.1.0.

### Test IKEv2.EN.I.1.2.6.3: Simultaneous CHILD_SA Rekeying

**Purpose:**

To verify an IKEv2 device properly handles simultaneous CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4718] - Sections 5.11.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                TN1
(End-Node)         (End-Node)
     |                  |
     |----------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                  | (Judgment #1)
     |<-----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                  | (Packet #1)
     |                  |
     |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                  | (Judgment #2)
     |<-----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                  | (Packet #2)
     |                  |
    ...                ...
     |                  |                           ---
     |<-----------------| IPsec {Echo Request}       |
     |                  | (Packet #3)                |
     |----------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
     |                  | (Judgment #3)              |
     |                  |                           ---
    ...                ...
     |                  |
     |----------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                  | (Judgment #4)
     |                  |
     |<-----------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Nr, TSi, TSr})
     |                  | (Packet #4)
     |----------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Ni, TSi, TSr})
     |                  | (Judgment #5)
     |                  |
     |<-----------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                  | (Packet #5)
     |                  |
     |----------------->| INFORMATIONAL request (HDR, SK {D})
     |                  | (Judgment #6)
     |<-----------------| INFORMATIONAL response (HDR, SK {D})
     |                  | (Packet #6)
     |                  |
     |----------------->| INFORMATIONAL request (HDR, SK {D})
     |                  | (Judgment #7)
     |<-----------------| INFORMATIONAL response (HDR, SK {D})
     |                  | (Packet #7)
     |                  |
     |<-----------------| IPsec {Echo Request}  (new CHILD_SA)
     |                  | (Packet #8)
     |----------------->| IPsec {Echo Reply}    (new CHILD_SA)
     |                  | (Judgment #8)
     V                  V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #13 |
| Packet #5 | See Common Packet #14 |
| Packet #6 | See below |
| Packet #7 | See below |
| Packet #8 | See Common Packet #19 |

Packet #6: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the original CHILD_SA |

Packet #7: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |

| | | |
|---|---|---|
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the new CHILD_SA initiated by the NUT at Step 9 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 transmits a CREATE_CHILD_SA request to rekey CHILD_SA to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with a CREATE_CHILD_SA response to the CRETE_CHILD_SA received at Step 9. The response message includes minimum Nonce Data.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response to the INFORMATIONAL request received at Step 13.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an INFORMATIONAL response to the INFORMATIONAL request received at Step 15.
17. TN1 transmits an Echo Request with IPsec ESP using the existing algorithms to the NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey a CHILD_SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence

Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the original CHILD_SA.

**Step 15: Judgment #7**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the new CHILD_SA initiated by the NUT at Step 9.

**Step 18: Judgment #8**
The NUT transmits an Echo Reply with IPsec ESP using the existing CHILD_SA initiated by the TN1 at Step 10.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.6.4: Simultaneous CHILD_SA Rekeying with retransmission

**Purpose:**

To verify an IKEv2 device properly handles simultaneous CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4718] - Sections 5.11.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Packet #2)
    |                |
   ...              ...
    |                |                        ---
    |<---------------| IPsec {Echo Request}     |
    |                | (Packet #3)              |
    |--------------->| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)            |
    |                |                        ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Nr, TSi, TSr})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Ni, TSi, TSr})
    |                | (Judgment #5)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #5)
    |--------------->| INFORMATIONAL response (HDR, SK {D})
    |                | (Judgment #6)
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Judgment #7)
    |<---------------| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)}
    |                | (Packet #6)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #7)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #8)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #13 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See Common Packet #19 |

Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |

| | | |
|---|---|---|
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the original CHILD_SA |

Packet #6: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #14 |
| UDP Header | | Same as Common Packet #14 |
| IKEv2 Header | | Same as Common Packet #14 |
| E Payload | | Same as Common Packet #14 |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | NO_PROPOSAL_CHOSEN (14) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 transmits a CREATE_CHILD_SA request to rekey CHILD_SA to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 transmits an INFORMAITONAL request with a Delete Payload to close the replaced

CHILD_SA.

13. Observe the messages transmitted on Link A.
14. Observe the messages transmitted on Link A.
15. TN1 responds with a CREATE_CHILD_SA response with a Notify payload of type NO_PROPOSAL_CHOSEN to the retransmitted CREATE_CHILD_SA request.
16. TN1 transmits an Echo Request with IPsec ESP using the existing algorithms to the NUT.
17. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey a CHILD_SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL response with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the original CHILD_SA.

**Step 14: Judgment #7**
The NUT retransmits the same CREATE_CHILD_SA request as the message at Step 11. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 17: Judgment #8**
The NUT transmits an Echo Reply with IPsec ESP using the existing CHILD_SA initiated by the TN1 at Step 10.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.6.5: Simultaneous IKE_SA Rekeying

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4718] - Sections 5.11.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
     |                 |
     |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                 | (Packet #2)
     |                 |
    ...               ...
     |                 |                          ---
     |<----------------| IPsec {Echo Request}      |
     |                 | (Packet #3)               |
     |---------------->| IPsec {Echo Reply}        | repeat Echo exchange until lifetime of SA is expired
     |                 | (Judgment #3)             |
     |                 |                          ---
    ...               ...
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                 | (Judgment #4)
     |                 |
     |<----------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                 | (Packet #4)
     |---------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                 | (Judgment #5)
     |                 |
     |<----------------| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                 | (Packet #5)
     |                 |
     |---------------->| INFORMATIONAL request (HDR, SK {D})
     |                 | (Judgment #6)
     |<----------------| INFORMATIONAL response (HDR, SK {})
     |                 | (Packet #6)
     |                 |
     |---------------->| INFORMATIONAL request (HDR, SK {D})
     |                 | (Judgment #7)
     |<----------------| INFORMATIONAL response (HDR, SK {})
     |                 | (Packet #7)
     |                 |
     |<----------------| INFORMATIONAL request (HDR, SK {})
     |                 | (Packet #8)
     |---------------->| INFORMATIONAL response (HDR, SK {})
     |                 | (Judgment #8)
     V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #11 |
| Packet #5 | See Common Packet #12 |
| Packet #6 | See Common Packet #18 |
| Packet #7 | See Common Packet #18 |
| Packet #8 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 responds with a CREATE_CHILD_SA response to the CREATE_CHILD_SA request received at Step 9. The response message includes minimum Nonce Data to make the NUT send a message to close duplicated IKE_SA.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response with no payload.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an INFORMATIONAL response with no payload.
17. TN1 transmits an INFORMATIONAL request with no payload to the NUT. The message is cryptographically protected by the new IKE_SA initiated by TN1 at Step 10.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey an IKE_SA. The message includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT responds a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the proposal in the SA payload Response has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's responder's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request . The message's IKE_SA Initiator's SPI value is the IKE_SA Initiator's SPI value of the original IKE_SA, and the message's IKE_SA Responder's SPI value is the IKE_SA Responder's SPI value of the original IKE_SA. The message also has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Step 15: Judgment #7**
The NUT transmits an INFORMATIONAL request . The message's IKE_SA Initiator's SPI value is the IKE_SA Initiator's SPI value of the new IKE_SA initiated by the NUT at Step 9, and the message's IKE_SA Responder's SPI value is the IKE_SA Responder's SPI value of the new IKE_SA initiated by the NUT at Step 9. The message also has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Step 18: Judgment #8**
The NUT transmits an INFOMATIONAL response with no payload.

**Possible Problems:**

- Each NUT has the different lifetime of SA

.

- Step 13 (INFORMATIONAL request to delete the original IKE_SA) can possibly switch the place with Step 15 (INFORMATIONAL request to delte the new IKE_SA).

## Test IKEv2.EN.I.1.2.6.6: Simultaneous IKE_SA Rekeying with retransmission

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4718] - Sections 5.11.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
(End-Node)          (End-Node)
    |                   |
    |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                   | (Judgment #1)
    |<------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                   | (Packet #1)
    |                   |
    |------------------>| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                   | (Judgment #2)
    |<------------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                   | (Packet #2)
    |                   |
   ...                 ...
    |                   |                         ---
    |<------------------| IPsec {Echo Request}     |
    |                   | (Packet #3)              |
    |------------------>| IPsec {Echo Reply}       | repeat Echo exchange until lifetime of SA is expired
    |                   | (Judgment #3)            |
    |                   |                         ---
   ...                 ...
    |                   |
    |------------------>| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                   | (Judgment #4)
    |                   |
    |<------------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                   | (Packet #4)
    |------------------>| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
    |                   | (Judgment #4)
    |                   |
    |<------------------| INFORMATIONAL request (HDR, SK {D})
    |                   | (Packet #5)
    |------------------>| INFORMATIONAL response (HDR, SK {})
    |                   | (Judgment #5)
    |                   |
    |-------X           | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                   | (Judgment #6)
    V                   V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #11 |
| Packet #5 | See below |

Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |

| | | |
|---|---|---|
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index | none |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA to the NUT.
11. Observe the messages transmitted on Link A.
12. TN1 transmits an INFORMATONAL request to close the original IKE_SA. The message has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.
13. Observe the messages transmitted on Link A.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey an IKE_SA. The message includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT responds a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the proposal in the SA payload Response has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's responder's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT responds with an INFOMATIONAL response to the INFORMATIONAL request to close the original IKE_SA.

**Step 14: Judgment #7**
The NUT never retransmits a CREATE_CHILD_SA request transmitted at Step 9.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.I.1.2.6.7: Rekeying a CHILD_SA while Closing a CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.8: Closing a New CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.9: Rekeying a New CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.10: Rekeying an IKE_SA with half-open CHILD_SAs

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.11: Rekeying a CHILD_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.12: Rekeying an IKE_SA with half-closed CHILD_SAs

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.13: Closing a CHILD_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.2.6.14: Closing an IKE_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

### Test IKEv2.EN.I.1.2.6.15: Rekeying an IKE _SA while Closing an IKE_SA

This test case was deleted at revision 1.1.0.

## Group 2.7. Non zero RESERVED fields

### Test IKEv2.EN.I.1.2.7.1: Non zero RESERVED fields in CREATE_CHILD_SA response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
 (End-Node)        (End-Node)
     |                 |
     |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Judgment #1)
     |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Packet #1)
     |                 |
     |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                 | (Judgment #2)
     |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                 | (Packet #2)
     |                 |
    ...               ...
     |                 |                          ---
     |<----------------| IPsec {Echo Request}       |
     |                 | (Packet #3)                |
     |---------------->| IPsec {Echo Reply}         | repeat Echo exchange until lifetime of SA is expired
     |                 | (Judgment #3)              |
     |                 |                          ---
    ...               ...
     |                 |
     |---------------->| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                 | (Judgment #4)
     |<----------------| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                 | (Packet #4)
     |                 |
     |---------------->| INFORMATIONAL request (HDR, SK {D})
     |                 | (Judgment #5)
     V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #4 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #14<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link A.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT. All RESERVED fields in the message are set to one.
11. Observe the messages transmitted on Link A.

**Observable Results:**

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Group 3. The INFORMATIONAL Exchange

## Group 3.1. Header and Payload Formats

### Test IKEv2.EN.I.1.3.1.1: Sending INFORMATIONAL Exchange

This test case was deleted at revision 1.1.0.

## Group 3.2. Use of Retransmission Timers

### Test IKEv2.EN.I.1.3.2.1: Retransmission of INFORMATIONAL request

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.I.1.3.2.2: Stop of retransmission of INFORMATIONAL request

This test case was deleted at revision 1.1.0.

## Group 3.3. Non zero RESERVED fields

### Test IKEv2.EN.I.1.3.3.1: Non zero RESERVED fields in INFORMATIONAL response

This test case was deleted at revision 1.1.0.

## Group 3.4. Error Handling

### Test IKEv2.EN.I.1.3.4.1: INVALID_SPI

This test case was deleted at revision 1.1.0.

## Section 1.1.2. Endpoint to Security Gateway Tunnel

## Group 1. The Initial Exchanges

## Group 1.1. Header and Payload Formats

### Test IKEv2.EN.I.2.1.1.1: Sending IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                 TN1
(End-Node)            (SGW)
    |                   |
    |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                   | (Judgment #1)
    |<------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                   | (Packet #1)
    |                   |
    |------------------>| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                   | (Judgment #2)
    |                   |
    V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: IKE Header Format (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response to the NUT.

8. Observe the messages transmitted on Link A.

*Part C: IDi Payload Format (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (ADVANCED)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (ADVANCED)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: TSi Payload Format (ADVANCED)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSr Payload Format (ADVANCED)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 35 Header format**

- An IKE_SA Initiator’s SPI field is set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field is set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field is set to Encrypted Payload (46).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to IKE_AUTH (35).
- A Flags field is set to (00010000)2 = (16)10.
- A Message ID field is set to 1.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 36 Encrypted payload**

- A Next Payload field is set to IDi Payload (35).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 37 ID Payload format**

- A Next Payload field is set to AUTH Payload (39).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field is set to ID_IPV6_ADDR (5).
- A RESERVED field is set to zero.
- An Identification Data field is set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 38 AUTH Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field is set to Shared Key Message Integrity Code (2).
- A RESERVED field is set to zero.
- An Authentication Data field is set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

```
                              1                   2                   3
          0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
         ! Next     44    !0!       0      ! Length           40            !              |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---           |
         !       0        !         0      ! Length           36            !  |           |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         ! Number    1    ! Prot ID    3   ! SPI Size   4    ! Trans Cnt  3  !  |           |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         ! SPI value                                                   !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       3        !         0      ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
        | ! Type  1  (EN) !         0      ! Transform ID     3     (3DES) !  | Proposal |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       3        !         0      ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | ! Type  3  (IN) !         0      ! Transform ID     2     (SHA1) !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       0        !         0      ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | ! Type  5  (ESN)!         0      ! Transform ID     0       (No)  !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 39 SA Payload contents**

The NUT transmits an IKE_AUTH request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 40 SA Payload format**

- A Next Payload field is set to TSi Payload (44).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 41 Proposal sub-structure format**

Transform field is set to following (There are 3 Transform Structures).

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field is set to 1 if this structure is the first proposal, otherwise set to 1 greater thatn the previous proposal.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to 4.
- A # of Transforms field is set to 3.
- A SPI field is set to the sending entity’s SPI (4 octets value)

Transform field is set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 42 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last proposal, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field is set to ESN (5).
- A RESERVED field is set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 43 TSi Payload format**

- A Next Payload field is set to TSr Payload (45).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to the number of actual traffic selectors.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 44 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to NUT address.
- A Ending Address field is set to greater thatn or equal to NUT address.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 45 TSr Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to the number of actual traffic selectors.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 46 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to less than or equal to Prefix Y.
- An Ending Address field is set to less than or equal to Prefix Y.

**Possible Problems:**

- IKE_AUTH request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDi,
[CERT+],
[N(INITIAL_CONTACT)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)], CERTREQ+],
[IDr],
AUTH,
[CP(CFG_REQUEST)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA,
TSi,
TSr,
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

- Each of transforms can be located in the any order.

## Test IKEv2.EN.I.2.1.1.2: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1              TH1
(End-Node)        (SGW)            (Host)
   |                |                |
   |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                |                | (Judgment #1)
   |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                |                | (Packet #1)
   |                |                |
   |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                |                | (Judgment #2)
   |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                |                | (Packet #2)
   |                |                |
   |<===============+----------------| IPsec {Echo Request}
   |                |                | (Packet #3)
   |================+--------------->| IPsec {Echo Reply}
   |                |                | (Judgment #3)
   |                |                |
   V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #20 |

*Part A (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH1 transmits an Echo Request and TN1 forwards an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Group 1.2. Requesting an Internal Address on a Remote Network

### Test IKEv2.EN.I.2.1.2.1: Sending CFG_REQUEST

**Purpose:**

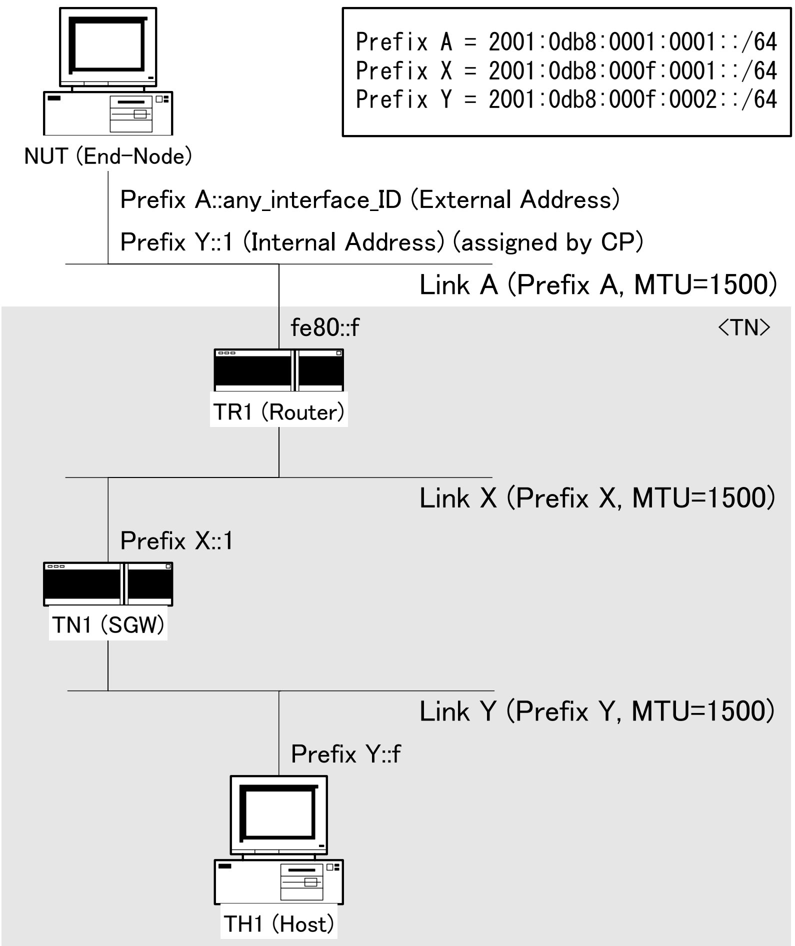
To verify an IKEv2 device transmits IKE_AUTH request using properly Configuration Payload format

**References:**

- [RFC 4306] - Sections 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REQUEST for

INTERNAL_IP6_ADDRESS. The traffic selector must be configured by the following table.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | Link Y | ANY | ANY | NUT (internal address) | ANY | ANY |
| **Outbound** | NUT (internal address) | ANY | ANY | Link Y | ANY | ANY |

* NUT must propose Traffic Selector covering above address range.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                TN1
(End-Node)          (SGW)
    |                 |
    |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Judgment #1)
    |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Packet #1)
    |                 |
    |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, CP(CFG_REQUEST), SAi2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    V                 V
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response to the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted Configuration Payload containing following values:

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C! RESERVED    !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   CFG Type    !                    RESERVED                   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Configuration Attributes                    ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 47 Configuration Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A CFG Type field is set to CFG_REQUEST (1).
- A RESERVED field is set to zero.

The following configuration attribute must be included in Configuration Attributes field.

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!R|         Attribute Type      !            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                             Value                             ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 48 Configuration Attributes format**

Configuration Attribute #1

- Reserved field is set to zero.
- Attribute Type field is set to INTERNAL_IP6_ADDRESS (8).
- Length field is set to zero.
- Value field is empty.

**Possible Problems:**

- The implementation may not set single configuration attribute by the implementation policy. In this case, Configuration Payload contains multiple configuration attributes.

## Test IKEv2.EN.I.2.1.2.2: Receipt of CFG_REPLY

**Purpose:**

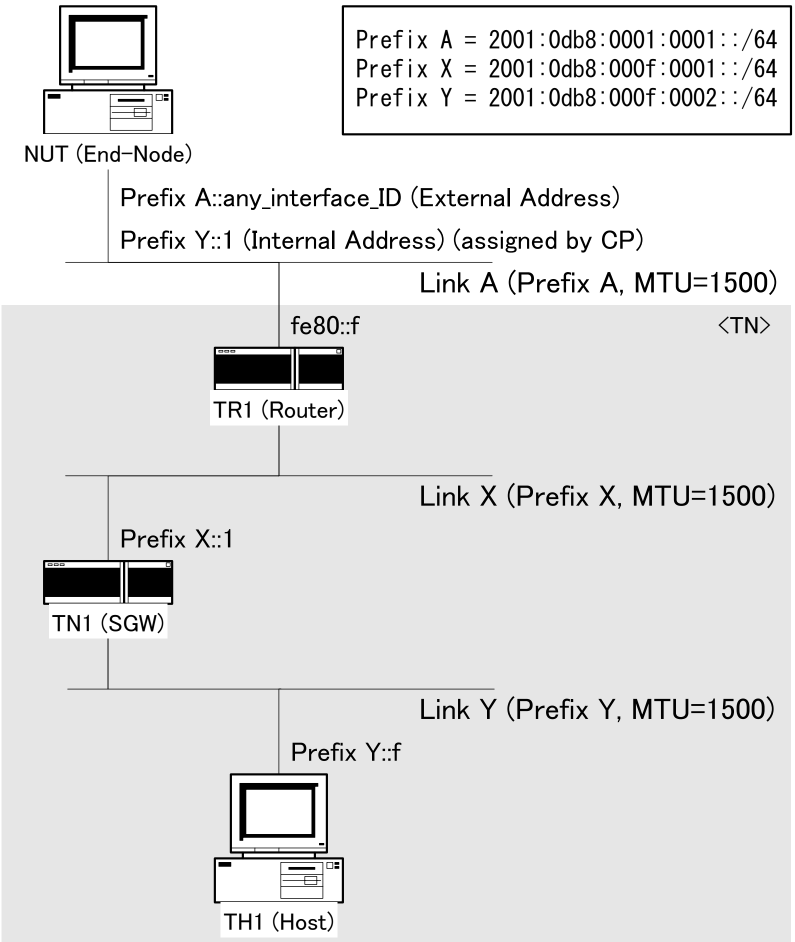
To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 2.19 and 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REQUEST for INTERNAL_IP6_ADDRESS. The traffic selector must be configured by the following table.

| | Traffic Selector | |
|---|---|---|
| | Source | Destination |

| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
|---|---|---|---|---|---|---|
| **Inbound** | Link Y | ANY | ANY | NUT (internal address) | ANY | ANY |
| **Outbound** | NUT (internal address) | ANY | ANY | Link Y | ANY | ANY |

* NUT must propose Traffic Selector covering above address range.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1              TH1
(End-Node)         (SGW)            (Host)
    |                |                |
    |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                |                | (Judgment #1)
    |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                |                | (Packet #1)
    |                |                |
    |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH,
    |                |                |                        CP(CFG_REQUEST), SAi2, TSi, TSr})
    |                |                | (Judgment #2)
    |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
    |                |                | (Packet #2)
    |                |                |
    |<===============+----------------| IPsec {Echo Request (sent to NUT internal address)}
    |                |                | (Packet #3)
    |================+--------------->| IPsec {Echo Reply (sent from NUT internal address)}
    |                |                | (Judgment #3)
    |                |                |
    V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Below |
| Packet #3 | See Below |

- Packet #2: IKE_AUTH response packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #6 | |
| UDP Header | Same as Common Packet #6 | |
| IKEv2 Header | Same as Common Packet #6 | |
| E Payload | Same as Common Packet #6 | |
| IDr Payload | Same as Common Packet #6 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #6 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 29 |
| | CFG Type | 2 (CFG_REPLY) |
| | RESERVED | 0 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #6 | |
| TSi Payload | Other fields are same as Common Packet #6 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #6 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 0 |

| | | | |
|---|---|---|---|
| | Attribute Type | INTERNAL_IP6_ADDRESS | |
| | Length | 17 | |
| | Value | IPv6 address | Prefix Y::1 |
| | | Prefix-length | 128 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | Prefix Y::1 |
| | Ending Address | Prefix Y::1 |

- Packet #3: Echo Request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #20 | |
| ESP | Same as Common Packet #20 | |
| IPv6 Header | Source Address | Prefyx Y::f |
| | Destination Address | Prefix Y::1 |
| ICMPv6 Header | Same as Common Packet #20 | |

*Part A (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH1 transmits an Echo Request to NUT internal address and TN1 forwards an Echo Request with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96. The inner packet is sent from NUT internal address.

**Possible Problems:**

- The implementation may not set single configuration attribute by the implementation policy. In this case, Configuration Payload contains multiple configuration attributes.

## Test IKEv2.EN.I.2.1.2.3: Non zero RESERVED fields in Configuration Payload

**Purpose:**

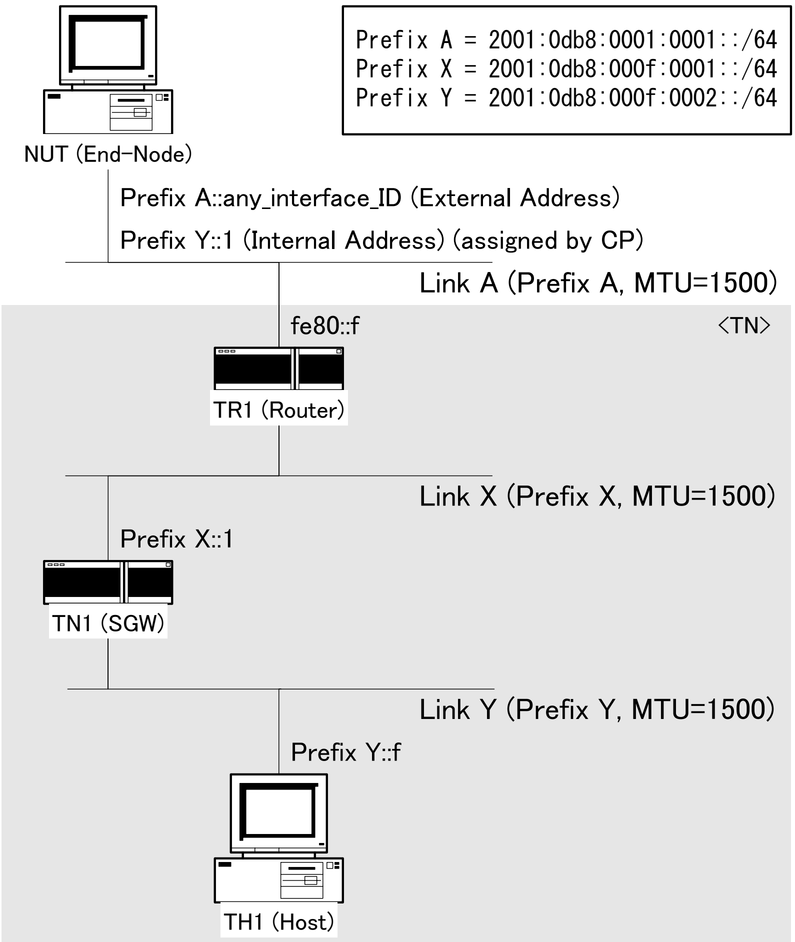
To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REQUEST for INTERNAL_IP6_ADDRESS. The traffic selector must be configured by the following table.

| | Traffic Selector | |
|---|---|---|
| | Source | Destination |

|  | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
|---|---|---|---|---|---|---|
| **Inbound** | Link Y | ANY | ANY | NUT (internal address) | ANY | ANY |
| **Outbound** | NUT (internal address) | ANY | ANY | Link Y | ANY | ANY |

* NUT must propose Traffic Selector covering above address range.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                   TN1                   TH1
(End-Node)             (SGW)                 (Host)
    |                    |                     |
    |------------->|                     | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                    |                     | (Judgment #1)
    |<-------------|                     | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                    |                     | (Packet #1)
    |                    |                     |
    |------------->|                     | IKE_AUTH request (HDR, SK {IDi, AUTH,
    |                    |                     |                          CP(CFG_REQUEST), SAi2, TSi, TSr})
    |                    |                     | (Judgment #2)
    |<-------------|                     | IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
    |                    |                     | (Packet #2)
    |                    |                     |
    |<=============+--------------| IPsec {Echo Request (sent to NUT internal address)}
    |                    |                     | (Packet #3)
    |==============+------------->| IPsec {Echo Reply (sent from NUT internal address)}
    |                    |                     | (Judgment #3)
    |                    |                     |
    V                    V                     V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Below |
| Packet #3 | See Below |

- Packet #2: IKE_AUTH response packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #6 | |
| UDP Header | Same as Common Packet #6 | |
| IKEv2 Header | Same as Common Packet #6 | |
| E Payload | Same as Common Packet #6 | |
| IDr Payload | Same as Common Packet #6 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #6 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 1 |
| | Payload Length | 29 |
| | CFG Type | 2 (CFG_REPLY) |
| | RESERVED | 1 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #6 | |
| TSi Payload | Other fields are same as Common Packet #6 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #6 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 1 |

| | | | |
|---|---|---|---|
| | Attribute Type | INTERNAL_IP6_ADDRESS | |
| | Length | 17 | |
| | Value | IPv6 address | Prefix Y::1 |
| | | Prefix-length | 128 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | Prefix Y::1 |
| | Ending Address | Prefix Y::1 |

- Packet #3: Echo Request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #20 | |
| ESP | Same as Common Packet #20 | |
| IPv6 Header | Source Address | Prefyx Y::f |
| | Destination Address | Prefix Y::1 |
| ICMPv6 Header | Same as Common Packet #20 | |

*Part A (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH1 transmits an Echo Request to NUT internal address and TN1 forwards an Echo Request with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES","AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96. The inner packet is sent from NUT internal address.

**Possible Problems:**

- The implementation may not set single configuration attribute by the implementation policy. In this case, Configuration Payload contains multiple configuration attributes.

## Test IKEv2.EN.I.2.1.2.4: Receipt of IKE_AUTH response without CFG_REPLY

**Purpose:**

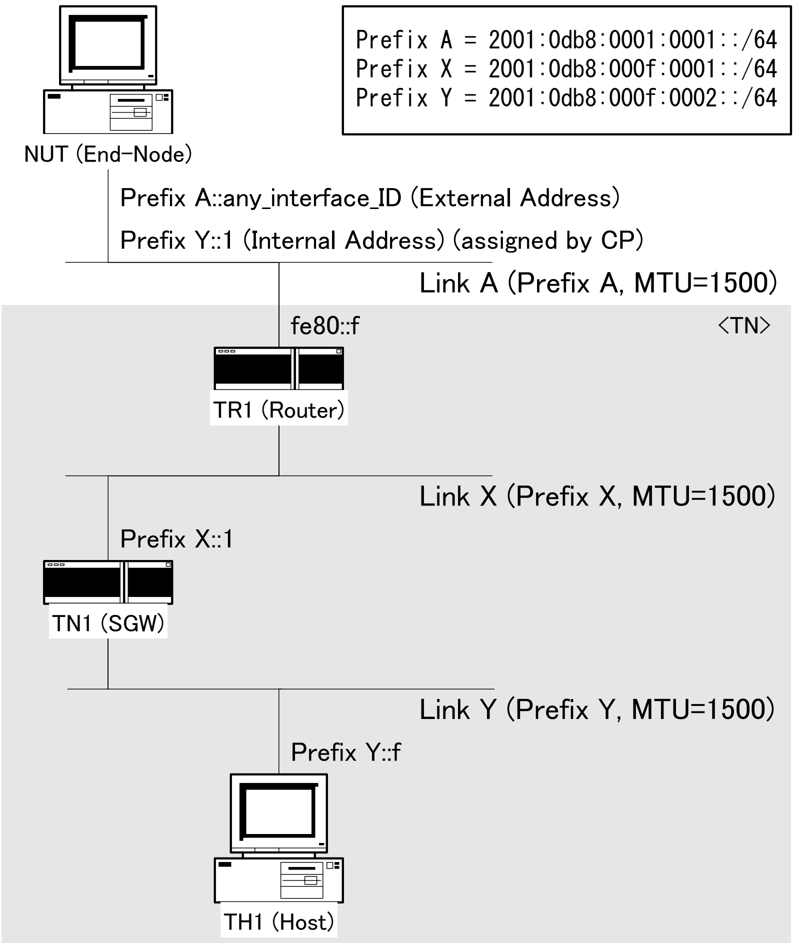
To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4718] - Sections 6.8

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REQUEST for INTERNAL_IP6_ADDRESS. The traffic selector must be configured by the following table.

| | Traffic Selector | |
|---|---|---|
| | **Source** | **Destination** |

| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
|---|---|---|---|---|---|---|
| **Inbound** | Link Y | ANY | ANY | NUT (internal address) | ANY | ANY |
| **Outbound** | NUT (internal address) | ANY | ANY | Link Y | ANY | ANY |

* NUT must propose Traffic Selector covering above address range.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                  TN1
(End-Node)             (SGW)
    |                    |
    |------------->|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                    |  (Judgment #1)
    |<--------------|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                    |  (Packet #1)
    |                    |
    |------------->|  IKE_AUTH request (HDR, SK {IDi, AUTH,
    |                    |                        CP(CFG_REQUEST), SAi2, TSi, TSr})
    |                    |  (Judgment #2)
    |<--------------|  IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                    |  (Packet #2)
    |                    |
    |<--------------|  INFORMATIONAL request (HDR, SK {})
    |                    |  (Packet #3)
    |------------->|  INFORMATIONAL response (HDR, SK {})
    |                    |  (Judgment #3)
    V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Below |
| Packet #3 | See Common Packet #17 |

- Packet #2: IKE_AUTH response packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #6 | |
| UDP Header | Same as Common Packet #6 | |
| IKEv2 Header | Same as Common Packet #6 | |
| E Payload | Same as Common Packet #6 | |
| IDr Payload | Same as Common Packet #6 | |
| AUTH Payload | Next Payload | 33 (SA) |
| | Other fields are same as Common Packet #6 | |
| SA Payload | Same as Common Packet #6 | |
| TSi Payload | Other fields are same as Common Packet #6 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #6 | |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | Prefix Y::1 |
| | Ending Address | Prefix Y::1 |

*Part A (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT. The message does not include any Configuration payloads.
6. TH1 transmits an INFORMATIONAL request with no payload to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with no payload to the TN1.

**Possible Problems:**

- The implementation may not set single configuration attribute by the implementation policy. In this case, Configuration Payload contains multiple configuration attributes.

## Test IKEv2.EN.I.2.1.2.5: Receipt of unrecognized Configuration Attributes

**Purpose:**

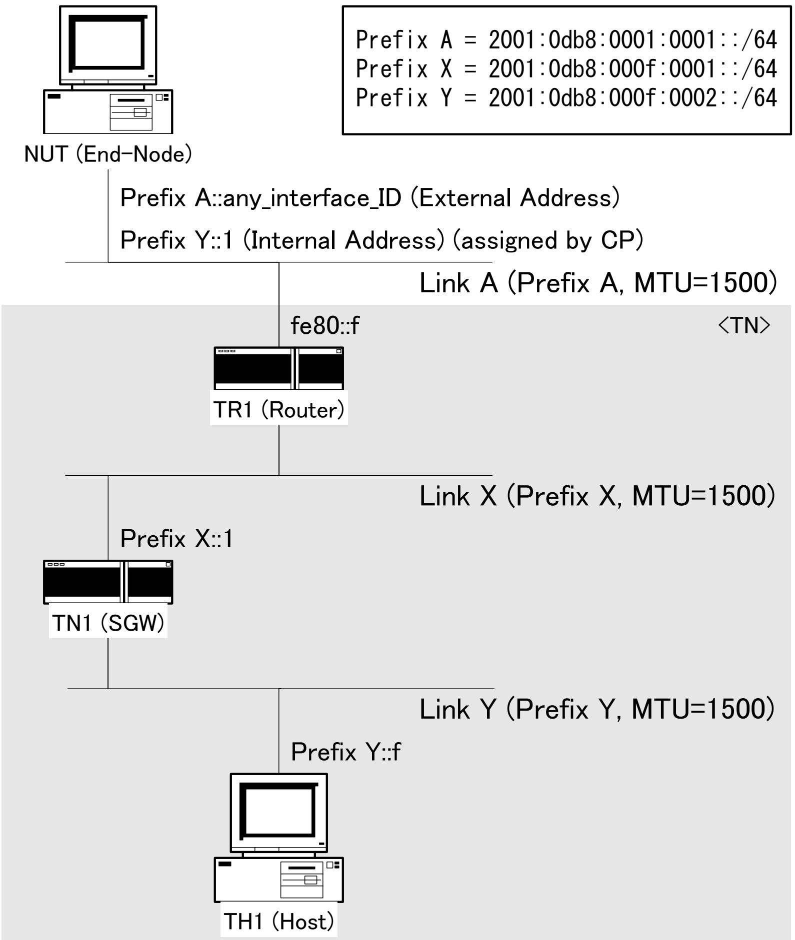
To verify an IKEv2 device properly handles unrecognized Configuration Attributes.

**References:**

- [RFC 4306] - Sections 2.19 and 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REQUEST for INTERNAL_IP6_ADDRESS. The traffic selector must be configured by the following table.

| | Traffic Selector | |
|---|---|---|
| | **Source** | **Destination** |

| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
|---|---|---|---|---|---|---|
| **Inbound** | Link Y | ANY | ANY | NUT (internal address) | ANY | ANY |
| **Outbound** | NUT (internal address) | ANY | ANY | Link Y | ANY | ANY |

* NUT must propose Traffic Selector covering above address range.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)        (SGW)
   |                |
   |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Judgment #1)
   |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Packet #1)
   |                |
   |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH,
   |                |                     CP(CFG_REQUEST), SAi2, TSi, TSr})
   |                | (Judgment #2)
   |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
   |                | (Packet #2)
   |                |
   |<---------------| INFORMATIONAL request (HDR, SK {})
   |                | (Packet #3)
   |--------------->| INFORMATIONAL response (HDR, SK {})
   |                | (Judgment #3)
   V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Below |
| Packet #3 | See Common Packet #17 |

- Packet #2: IKE_AUTH response packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #6 | |
| UDP Header | Same as Common Packet #6 | |
| IKEv2 Header | Same as Common Packet #6 | |
| E Payload | Same as Common Packet #6 | |
| IDr Payload | Same as Common Packet #6 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #6 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 29 |
| | CFG Type | 2 (CFG_REPLY) |
| | RESERVED | 0 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #6 | |
| TSi Payload | Other fields are same as Common Packet #6 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #6 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 0 |
| | Attribute Type | 32767 |

| | | | |
|---|---|---|---|
| | Length | 17 | |
| | Value | IPv6 address | Prefix Y::1 |
| | | Prefix-length | 128 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | Prefix Y::1 |
| | Ending Address | Prefix Y::1 |

*Part A (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT. The message includes a Configuration Attribute of unrecognized Attribute Type.
6. TH1 transmits an INFORMATIONAL request with no payload to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with no payload to the TN1.

**Possible Problems:**

- The implementation may not set single configuration attribute by the implementation policy. In this case, Configuration Payload contains multiple configuration attributes.

## Section 1.2. Responder

### Section 1.2.1. Endpoint-to-Endpoint Transport

#### Group 1. The Initial Exchanges

## Group 1.1. Header and Payload Formats

### Test IKEv2.EN.R.1.1.1.1: Sending IKE_SA_INIT response

**Purpose:**

To verify an IKEv2 device transmits an IKE_SA_INIT response using properly Header and Payloads format

**References:**

- [RFC4306] - Section 1.2, 2.10, 3.1, 3.2, 3.3, 3.4 and 3.9
- [RFC 4718] - Sections 7.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     V                V
```

| Packet #1 | See Common Packet #1 |
|---|---|

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B: SA Payload Format (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C: KE Payload Format (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

*Part D: Nonce Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 49 Header format**

- An IKE_SA Initiator’s SPI field is set to IKE_SA Initiator’s SPI field value supplied in the first IKE_SA_INIT request message.
- An IKE_SA Responder’s SPI field is set to a 64-bits value chosen by the NUT. It MUST not be zero.
- A Next Payload field is set to SA Payload (33).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to IKE_SA_INIT (34).
- A Flags field is set to (00000100)2 = (4)10.
- A Message ID field is set to zero.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 4: Judgment #1**

```
                      1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
 ! Next     34   !0!      0      ! Length          44            !             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---         |
 !       0       !       0       ! Length          40            ! |           |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
 ! Number    1   ! Prot ID   1   ! SPI Size  0   ! Trans Cnt  4  ! |           |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       3       !       0       ! Length           8            ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | ! Type  1  (EN) !       0       ! Transform ID     3     (3DES) ! |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       3       !       0       ! Length           8            ! |           |SA Payload
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |Proposal   |
          | ! Type  2  (PR) !       0       ! Transform ID     2     (SHA1) ! |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       3       !       0       ! Length           8            ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | ! Type  3  (IN) !       0       ! Transform ID     2     (SHA1) ! |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       0       !       0       ! Length           8            ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | ! Type  4  (DH) !       0       ! Transform ID     2     (1024) ! |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 50 SA Payload contents**

The NUT transmits an IKE_SA_INIT response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 51 SA Payload format**

- A Next Payload field is set to KE Payload (34).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 52 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 40 bytes for this proposal according to Common Configuration.
- A Proposal # field is set to 1.
- A Protocol ID field is set to IKE (1).
- A SPI Size field is set to zero.
- A # of Transforms field is set to 4.

A Transform field is set to following (There are 4 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 53 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.

- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for PRF_HMAC_SHA1.
- A Transform Type field is set to PRF (2).
- A RESERVED field is set to zero.
- A Transform ID set to PRF_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #4

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for 1024 MODP Group.
- A Transform Type field is set to D-H (4).
- A RESERVED field is set to zero.
- A Transform ID set to Group2 (2).

*Part C*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including properly formatted KE Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!          DH Group #           !           RESERVED            !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Key Exchange Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 54 KE Payload format**

- A Next Payload field is set to Nonce Payload (40).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 136 bytes for Group 2.
- A DH Group field is set to Group2 (2).
- A RESERVED field is set to zero.
- A Key Exchange Data field is set to Diffie-Hellman public value. The length of

the Key Exchange Data field must be equal to 1024bit.

- The length of the Key Exchange Data field must be equal to 1024bit.

*Part D*

**Step 8: Judgment #4**

The NUT transmits an IKE_SA_INIT response including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 55 Nonce Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Nonce Data field is set to random data generated by the transmitting entity.
- The size of the Nonce must between 16 and 256 octets.

**Possible Problems:**

- IKE_SA_INIT response has following packet format. It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
SA, KE, Nr,
[N(NAT_DETECTION_SOURCE_IP),
 N(NAT_DETECTION_DESTINATION_IP)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)],
  CERTREQ+],
[V+]
```

- Each of transforms can be located in the any order.

## Test IKEv2.EN.R.1.1.1.2: Sending IKE_AUTH response

**Purpose:**

To verify an IKEv2 device transmits an IKE_AUHT response using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: IDr Payload Format (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: Notify Payload Format (BASIC)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: SA Payload Format (BASIC)*

21. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSi Payload Format (BASIC)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
28. Observe the messages transmitted on Link A.

*Part H: TSr Payload Format (BASIC)*

29. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
30. Observe the messages transmitted on Link A.
31. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
32. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 56 Header format**

- An IKE_SA Initiator's SPI field is set to same as the IKE_SA_INIT request's IKE_SA Initiator's SPI field value.
- An IKE_SA Responder's SPI field is set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field is set to Encrypted Payload (46).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to IKE_AUTH (35).
- A Flags field is set to (00000100)2 = (4)10.
- A Message ID field is set to 1.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 57 Encrypted payload**

- A Next Payload field is set to IDr Payload (36).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 58 ID Payload format**

- A Next Payload field is set to AUTH Payload (39).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field is set to ID_IPV6_ADDR (5).
- A RESERVED field is set to zero.
- An Identification Data field is set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 59 AUTH Payload format**

- A Next Payload field is set to Notify Payload (41).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1
- An Auth Method field is set to Shared Key Message Integrity Code (2).
- A RESERVED field is set to zero.
- An Authentication Data field is set to correct authentication value.

*Part E*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 60 Notify Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 8 bytes for USE_TRANSPORT.
- A Protocol ID field is set to IKE_SA (1).
- A SPI Size field is set to zero.
- A Notify Message Type field is set to USE_TRANSPORT_MODE (16391)

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 24: Judgment #2**

```
                            1                   2                   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
       ! Next     44    !0!      0      ! Length          40            !             |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---           |
       !       0        !        0      ! Length          36            !  |          |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
       ! Number     1   ! Prot ID    3  ! SPI Size   4  ! Trans Cnt  3  !  |          |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
       ! SPI value                                                      !  |          |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
      | !       3        !        0      ! Length           8            !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |SA Payload
      | ! Type  1  (EN) !        0      ! Transform ID      3      (3DES) !  | Proposal |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
      | !       3        !        0      ! Length           8            !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
      | ! Type  3  (IN) !        0      ! Transform ID      2      (SHA1) !  |          |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
      | !       0        !        0      ! Length           8            !  |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
      | ! Type  5  (ESN)!        0      ! Transform ID      0        (No)  !  |          |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 61 SA Payload contents**

The NUT transmits an IKE_AUTH response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 62 SA Payload format**

- A Next Payload field is set to TSi Payload (44).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 63 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field is set to 1.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to 4.
- A # of Transforms field is set to 3.
- A SPI field is set to the sending entity’s SPI (4 octets value)

Transform field is set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 64 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.

- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field is set to ESN (5).
- A RESERVED field is set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part G*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 65 TSi Payload format**

- A Next Payload field is set to TSr Payload (45).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to 1.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 66 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to TN1 address.
- An Ending Address field is set to TN1 address.

*Part H*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 67 TSr Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to 1.
- A RESERVED field is set to zero.

Traffic Selectors field is set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 68 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to NUT address.
- An Ending Address field is set to NUT address.

**Possible Problems:**

- IKE_AUTH response has following packet format. It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDr,
[CERT+],
AUTH,
[CP(CFG_REPLY)],
[N(IPCOMP_SUPPORTED)],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA,
TSi,
TSr,
[N(ADDITIONAL_TS_POSSIBLE)],
[V+]
```

- Each of transforms can be located in the any order.

## Test IKEv2.EN.R.1.1.1.3: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles CHILD_SA negotiated by the Initial Exchanges using Pre-shared key.

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.

6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Group 1.2. Use of Retransmission Timers

### Test IKEv2.EN.R.1.1.2.1: Receipt of retransmitted IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device transmits an IKE_SA_INIT response when the device received a retransmitted IKE_SA_INIT request.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |               * wait until retrans timer expires
    |-------X       | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #2)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #2)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #3)
    |               |
    V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #1<br>(The Message ID is the same as Packet #1) |

*Part A: (BASIC)*

1. TN starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. Observe the messages transmitted on Link A.
4. TN1 retransmits same IKE_SA_INIT request as the message transmitted in Step 1 to the

NUT.

5. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 3: Judgment #2**
The NUT never retransmits the same IKE_SA_INIT response as the response transmitted at Step 2.

**Step 5: Judgment #3**
The NUT transmits the same IKE_SA_INIT response as the response transmitted at Step 2.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.2.2: Receipt of retransmitted IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits an IKE_AUTH response when the device received a retransmitted IKE_AUTH request.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                |  (Packet #1)
     |--------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                |  (Judgment #1)
     |                |
     |<---------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                |  (Packet #2)
     |--------------->|  IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                |  (Judgment #2)
     |                |
     |                *  wait until retrans timer expires
     |-------X        |  IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                |  (Judgment #3)
     |                |
     |<---------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                |  (Packet #3)
     |--------------->|  IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                |  (Judgment #4)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #3<br>(The Message ID is the same as Packet #1) |

*Part A: (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.

2. Observe the messages transmitted on Link A.
3. After reception of an IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. Observe the messages transmitted on Link A.
6. TN1 retransmits the same IKE_AUTH request as the request transmitted in Step 3 to the NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 5: Judgment #3**
The NUT never retransmits the same IKE_AUTH response as the response transmitted at Step 4.

**Step 7: Judgment #4**
The NUT transmits the same IKE_AUTH response as the response transmitted at Step 4.

**Possible Problems:**

- None.

## Group 1.3. State Synchronization and Connection Timeouts

### Test IKEv2.EN.R.1.1.3.1: State Synchronization with ICMP messages

**Purpose:**

To verify that an IKEv2 device doesn't conclude that the other endpoint has faild by receiving ICMP Error messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TR1              TN1
(End-Node)       (Router)        (End-Node)
    |                |                |
    |<---------------+----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                |                | (Packet #1)
    |----------------+--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                |                | (Judgment #1)
    |                |                |
    |<---------------+----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                |                | (Packet #2)
    |----------------+--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                |                | (Judgment #2)
    |                |                |
    |<---------------+----------------| IPsec {Echo Request}
    |                |                | (Packet #3)
    |----------------+--------------->| IPsec {Echo Reply}
    |                |                | (Judgment #3)
    |                |                |
    |<---------------|                | Destination Unreachable (No route to destination)
    |                |                | (Packet #4)
    |                |                |
    |<---------------+----------------| IPsec {Echo Request}
    |                |                | (Packet #5)
    |----------------+--------------->| IPsec {Echo Reply}
    |                |                | (Judgment #4)
    |                |                |
    V                V                V

N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #1 |
|---|---|

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |
| Packet #5 | See Common Packet #19 |

- Packet #4: ICMPv6 Destination Unreachable

| | | |
|---|---|---|
| IPv6 Header | Source Address | TR1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link A |
| ICMPv6 Header | Type | 1 |
| | Code | 0 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. After reception of an Echo Reply from NUT, TR1 transmits ICMP Destination Unreachable Message to the NUT.
8. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.3.2: State Synchronization with IKE messages

**Purpose:**

To verify that an IKEv2 device doesn't conclude that the other endpoint has faild by receiving cryptographicaly unprotected IKE message.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #3)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #3)
     |                |
     |<---------------| cryptographically unprotected IKE message
     |                | (Packet #4)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #5)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #4)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |

| Packet #5 | See Common Packet #19 |
|---|---|

- Packet #4: cryptographicaly unprotected INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link X |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | any |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 0 |
| | Notify Message Type | 11 (INVALID_SPI) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. After reception of an Echo Reply from NUT, TN1 transmits a cryptographically unprotected INFORMATIONAL request with Notify payload of type INVALID_ SPI to the NUT.
8. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None

## Test IKEv2.EN.R.1.1.3.3: Close connections when receiving INITIAL_CONTACT

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.1.3.4: Receiving Liveness check

**Purpose:**

To verify that an IKEv2 device can respond to INFORMATIONAL request for liveness check.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    |<--------------| INFORMATIONAL request (HDR, SK {})
    |               | (Packet #3)
    |-------------->| INFORMATIONAL response (HDR, SK {})
    |               | (Judgment #3)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #17 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an

INFORMATIONAL request with no payloads.

6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

## Test IKEv2.EN.R.1.1.3.5: Receiving Delete Payload for IKE_SA

**Purpose:**

To verify an IKEv2 device can respond to INFORMATIONAL request with a Delete Payload, when IKE_SA is deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK {D})
     |                | (Packet #3)
     |--------------->| INFORMATIONAL response (HDR, SK {})
     |                | (Judgment #3)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |

| | | |
|---|---|---|
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 2 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index | none |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with a Delete payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with no payloads.

**Possible Problems:**

- None

## Test IKEv2.EN.R.1.1.3.6: Receiving Delete Payload for CHILD_SA

**Purpose:**

To verify an IKEv2 device can respond to INFORMATIONAL request with a Delete Payload, when CHILD_SAs are deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK {D})
     |                | (Packet #3)
     |--------------->| INFORMATIONAL response (HDR, SK {D})
     |                | (Judgment #3)
     |                |
     V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |

| | | |
|---|---|---|
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 2 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value to be deleted |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with a Delete payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the TN1's inbound SPI value to be deleted as SPI value.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with a Delete payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the NUT's inbound SPI value to be deleted as SPI value.

**Possible Problems:**

- None

## Group 1.4. Version Numbers and Forward Compatibility

### Test IKEv2.EN.R.1.1.4.1: Receipt of a higher minor version number

**Purpose:**

To verify an IKEv2 device aceepts a request with a higher minor version number and respond to the request.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    V               V
```

| | |
|---|---|
| Packet #1 | See below |

- Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Other fields are same as the Common Packet #1 | |
| | Major Version | 2 |
| | Minor Version | 1 |
| SA Payload | Same as the Common Packet #1 | |
| KE Payload | Same as the Common Packet #1 | |
| Ni, Nr Payload | Same as the Common Packet #1 | |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request with a higher minor version number.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.4.2: Receipt of a higher major version number

**Purpose:**

To verify an IKEv2 device drops a request with a higher major version number and send a notification message.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, N(INVALID_MAJOR_VERSION))
    |                | (Judgment #1)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See below |

Packet#1:

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Other fields are same as the Common Packet #1 | |
| | Major Version | 3 |
| SA Payload | Same as the Common Packet #1 | |
| KE Payload | Same as the Common Packet #1 | |
| Ni Payload | Same as the Common Packet #1 | |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response with a Notify payload of type INVALID_MAJOR_VERSION containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 69 Notify Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A SPI Size field is set to zero.
- A Notify Message Type field is set to INVALID_MAJOR_VERSION (5).
- A Notification Data field is set to the highest version number it supports (2).

**Possible Problems:**

- None.

# Test IKEv2.EN.R.1.1.4.3: Unrecognized payload types and critical bit is not set

**Purpose:**

To verify an IKEv2 device ignores invalid payload types when the invalid type payload's critical bit is not set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
      |                |
      |<---------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
      |                |  (Packet #1)
      |--------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
      |                |  (Judgment #1)
      |                |
      |<---------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
      |                |  (Packet #2)
      |--------------->|  IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
      |                |  (Judgment #2)
      |                |
      |<---------------|  CREATE_CHILD_SA request (HDR, SK {P, N, N+, SA, Ni, TSi, TSr})
      |                |  (Packet #3)
      |--------------->|  CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
      |                |  (Judgment #3)
      |                |
      V                V

 P: Payload with an invalid payload type
 N: REKEY_SA
 N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #13 Payload | |
| UDP Header | All fields are same as Common Packet #13 Payload | |
| IKEv2 Header | All fields are same as Common Packet #13 Payload | |
| E Payload | Next Payload | *Invalid payload type value* |

| | | |
|---|---|---|
| | Other fields are same as Common Packet #13 | |
| Invalid Payload | Next Payoad | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 4 |
| N Payload | All fields are same as Common Packet #13 Payload | |
| N Payload | All fields are same as Common Packet #13 Payload | |
| SA Payload | All fields are same as Common Packet #13 Payload | |
| Ni, Nr Paylaod | All fields are same as Common Packet #13 Payload | |
| TSi Paylaod | All fields are same as Common Packet #13 Payload | |
| TSr Payload | All fields are same as Common Packet #13 Payload | |

*Part A: Invalid payload type 1 (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 1 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 32 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 49 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload

type to the NUT. The E payload's IKE Header Next Payload field is set to 255 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.

24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

# Test IKEv2.EN.R.1.1.4.4: Unrecognized payload types and critical bit is set

**Purpose:**

To verify an IKEv2 device drops invalid payload types when the invalid type payload's critical bit is set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, P, N+, SA, Ni, TSi, TSr})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N(UNSUPPORTED_CRITICAL_PAYLOAD)})
    |                | (Judgment #3)
    |                |
    V                V

P: Payload with an invalid payload type
N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #13 Payload |
| UDP Header | All fields are same as Common Packet #13 Payload |
| IKEv2 Header | All fields are same as Common Packet #13 Payload |
| E Payload | All fields are same as Common Packet #13 Payload |

| | | |
|---|---|---|
| N Payload | All fields are same as Common Packet #13 Payload | |
| N Payload | Next Payoad | *Invalid payload type value* |
| | Other fields are same as Common Packet #13 | |
| Invalid Payload | Next Payoad | 33 (SA) |
| | Critical | 1 |
| | Reserved | 0 |
| | Payload Length | 4 |
| SA Payload | All fields are same as Common Packet #13 Payload | |
| Ni, Nr Paylaod | All fields are same as Common Packet #13 Payload | |
| TSi Paylaod | All fields are same as Common Packet #13 Payload | |
| TSr Payload | All fields are same as Common Packet #13 Payload | |

*Part A: Invalid payload type 1 and Critical bit is set (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 1 and the pointed pyaload's Critical bit is set.
6. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 and Critical bit is set (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 32 and the pointed pyaload's Critical bit is set.
12. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 and Critical bit is set (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 49 and the pointed pyaload's Critical bit is set.
18. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 and Critical bit is set (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH response from the NUT, TN1 transmits a

CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 255 and the pointed pyaload's Critical bit is set.
24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (1).

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (32).

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (49).

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (255).

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.4.5: Invalid Order Payloads

**Purpose:**

To verify an IKEv2 device properly handles IKE message with invalid order payloads.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<-------------| IKE_SA_INIT request (HDR, SAi1, Ni, KEi)
    |                | (Packet #1)
    |-------X        | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>KEi payload and Ni payload replace each other. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT never transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Group 1.5. Cookies

### Test IKEv2.EN.R.1.1.5.1: Cookies

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.1.5.2: Invalid Cookies

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.1.5.3: Interaction of COOKIE and INVALID_KE_PAYLOAD

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.1.5.4: Interaction of COOKIE and INVALID_KE_PAYLOAD with unoptimized Initiator

This test case was deleted at revision 1.1.0.

# Group 1.6. Cryptographic Algorithm Negotiation

## Test IKEv2.EN.R.1.1.6.1: Cryptographic Algorithm Negotiation for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles various algorithms for IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part H, configure the devices according to the Common Configuration except for *Italic* parameters.

| | **IKE_SA_INIT exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ***ENCR_AES_CBC*** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | DELETED | DELETED | DELETED | DELETED |
| **Part C** | ENCR_3DES | ***PRF_AES128_CBC*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_AES_XCBC_96*** | Group 2 |
| **Part E** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 14*** |
| **Part F** | ENCR_3DES | ***PRF_HMAC_SHA2_256*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part G** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_HMAC_SHA2_256_128*** | Group 2 |
| **Part H** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 24*** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)       (End-Node)
    |                 |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |

Packet #1: IKE_SA_INIT request

Packet #1 is same as Common Packet #1 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part B:

This test case is deleted at revision 1.0.4.

Part C:

SA Transform of Tranform Type PRF is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (AES128_XCBC) |

Part D:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 5 (AES_XCBC_96) |

Part E:

SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 4 (D-H) |
| | Reserved | 0 |
| | Transform ID | 14 (2048 MODP Group) |

Part F:

SA Transform of Tranform Type PRF is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 5 (HMAC_SHA2_256) |

Part G:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 12 (HMAC_SHA2_256_128) |

Part H:
SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 4 (D-H) |
| | Reserved | 0 |
| | Transform ID | 24 (2048-bit MODP Group with 256-bit Prime Order Subgroup) |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

This test case is deleted at revision 1.0.4.

*Part C: PRF PRF_AES128_CBC (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: D-H Group Group 14 (ADVANCED)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: PRF PRF_HMAC_SHA2_256 (ADVANCED)*

21. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.

24. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
28. Observe the messages transmitted on Link A.

*Part H: D-H Group Group 24 (ADVANCED)*

29. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
30. Observe the messages transmitted on Link A.
31. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
32. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

This test case is deleted at revision 1.0.4.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part D*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_AES_XCBC_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as accepted algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA2_256", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 24: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA2_256_128" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part H*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 24" as accepted algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.2: Cryptographic Algorithm Negotiation for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles various algorithms for CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

From part A to part G, TN1 transmits an IKE_AUTH request including a SA payload which contains the transforms as follows:

| | **IKE_AUTH exchanges Algorithms** | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **Extended Sequence Numbers** |
| **Part A** | *ENCR_AES_CBC* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part B** | *ENCR_AES_CTR* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part C** | *ENCR_NULL* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part D** | ENCR_3DES | *AUTH_AES_XCBC_96* | No Extended Sequence Numbers |
| **Part E** | ENCR_3DES | *NONE* | No Extended Sequence Numbers |
| **Part F** | ENCR_3DES | AUTH_HMAC_SHA1_96 | *Extended Sequence Numbers* |
| **Part G** | ENCR_3DES | ***AUTH_HMAC_SHA2_256_128*** | No Extended Sequence Numbers |

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #3)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #3)
    |               |
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH request

Packet #2 is same as Common Packet #3 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part B:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 13 (AES_CTR) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part C:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 1 (ENCR) |
| | Reserved | 0 |
| | Transform ID | 11 (ENCR_NULL) |

Part D:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 5 (AES_XCBC_96) |

Part E:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 0 (NONE) |

Part F:

SA Transform of Tranform Type ESN is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 5 (ESN) |
| | Reserved | 0 |
| | Transform ID | 1 (Extended Sequence Numbers) |

Part G:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 12 (HMAC_SHA2_256_128) |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Encryption Algorithm ENCR_NULL (ADVANCED)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.

22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
24. Observe the messages transmitted on Link A.

*Part E: Integrity Algorithm NONE (ADVANCED)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
28. Observe the messages transmitted on Link A.
29. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
30. Observe the messages transmitted on Link A.

*Part F: Extended Sequence Numbers (ADVANCED)*

31. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
32. Observe the messages transmitted on Link A.
33. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
34. Observe the messages transmitted on Link A.
35. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
36. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

37. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
38. Observe the messages transmitted on Link A.
39. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
40. Observe the messages transmitted on Link A.
41. After reception of IKE_AUTH response from the NUT, TN transmits an Echo Request with IPsec ESP with the accepted cryptographic suite to the NUT.
42. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_AES_CTR", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_NULL", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part D*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part E*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "NONE" and "No Extended Sequence Numbers" as accepted algorithms.  However, the transform indicating "NONE" can be omitted.

**Step 30: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part F*

**Step 32: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 34: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "Extended Sequence Numbers" as accepted algorithms.

**Step 36: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part G*

**Step 38: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 40: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA2_256_128" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 42: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.3: Receiving Multiple Transforms for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT request with an multiple transforms.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
(End-Node)          (End-Node)
   |                   |
   |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Packet #1)
   |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Judgment #1)
   V                   V
```

| Packet #1 | See below |
|---|---|

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the transforms as follows:

| | **IKE_SA_INIT exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_AES_CBC**<br>**ENCR_3DES** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_AES128_CBC**<br>**PRF_HMAC_SHA1** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96**<br>**AUTH_HMAC_SHA1_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or**<br>**Group 24,**<br>**Group 2** |

- Packet #1 IKE_SA_INIT request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #1 |
| UDP Header | Same as the Common Packet #1 |
| IKEv2 Header | Same as the Common Packet #1 |
| SA Payload | Other fields are same as the common packet #1 |

| | | |
|---|---|---|
| | SA Proposals | See SA Table below |
| KE Payload | Same as the Common Packet #1 | |
| Ni, Nr Payload | Same as the Common Packet #1 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
6. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload

as described above.

8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.4: Receiving Multiple Proposals for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT request with multiple proposals.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
(End-Node)         (End-Node)
   |                   |
   |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Packet #1)
   |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Judgment #1)
   V                   V
```

| Packet #1 | See below |
|---|---|

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the proposals as follows:

| | IKE_SA_INIT exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | Proposals | Protocol ID | Encryption | PRF | Integrity | D-H Group |
| Part A | Proposal #1 | IKE | **ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part B | Proposal #1 | IKE | ENCR_3DES | **PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part C | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96** | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part D | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or Group 24** |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

- Packet #1 IKE_SA_INIT request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #1 |
| UDP Header | Same as the Common Packet #1 |
| IKEv2 Header | Same as the Common Packet #1 |
| SA Payload | Other fields are same as the common packet #1 |

| | | |
|---|---|---|
| | SA Proposals | See SA Table below |
| KE Payload | Same as the Common Packet #1 | |
| Ni, Nr Payload | Same as the Common Packet #1 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 2 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
6. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.5: Receiving Multiple Transforms for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles an IKE_AUTH request with multiple transforms.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

From part A to part C, TN1 transmits an IKE_AUTH request including a SA payload which contains the transforms as follows:

| | **IKE_AUTH exchanges Algorithms** | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Other fields are same as the Common Packet #3 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #3 | |
| TSr Payload | Same as the Common Packet #3 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.6: Receiving Multiple Proposals for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles an IKE_AUTH request with multiple proposals.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

TN1 transmits an IKE_AUTH request including a SA payload which contains the two proposals as follows:

| | **IKE_AUTH exchanges Algorithms** | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | **ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | Proposal #1 | ESP | ENCR_3DES | **AUTH_AES_XCBC_96** | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part C** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | **ESN** |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Other fields are same as the Common Packet #3 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #3 | |
| TSr Payload | Same as the Common Packet #3 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 2 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.7: Sending INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles a KE payload which has different D-H Group # from accepted D-H Group #.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. Enable PFS.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA(DH#2, DH#14), Ni, KEi(DH#14), TSi, TSr})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK { N(INVALID_KE_PAYLOAD(DH#2)) })
    |                | (Judgment #3)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA(DH#2, DH#14), Ni, KEi(DH#2), TSi, TSr})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA(DH#2), Nr, KEr(DH#2), TSi, TSr})
    |                | (Judgment #4)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |
| Packet #4 | See below |

Packet #3: CREATE_CHILD_SA request for rekeying CHILD_SA

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #13 | |
| UDP Header | Same as the Common Packet #13 | |
| IKEv2 Header | Same as the Common Packet #13 | |
| E Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| SA Payload | Other fields are same as the Common Packet #13 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Other fields are same as the Common Packet #13 | |
| | Next Payload | 34 (KE) |
| KEi Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 264 |
| | DH Group # | 14 |
| | Reserved | 0 |
| | Key Exchange Data | DH#14 public key value |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

SA Payloads

| | | | |
|---|---|---|---|
| SA Proposal | Next Payload | | 0 (last) |
| | Reserved | | 0 |
| | Proposal Length | | 48 |
| | Proposal # | | 1 |
| | Protocol ID | | 1 (IKE) |
| | SPI Size | | 0 |
| | # of Transforms | | 5 |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 1 (ENCR) |
| | | Reserved | 0 |
| | | Transform ID | 3 (3DES) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 2 (PRF) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 3 (INTEG) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1_96) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 2 (1024 MODP Group) |
| | SA Transform | Next Payload | 0 (last) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 14 (2048 MODP Group) |

Packet #4: CREATE_CHILD_SA request for rekeying CHILD_SA

| | |
|---|---|
| IPv6 Header | Other fields are same as the Common Packet #13 |
| UDP Header | Other fields are same as the Common Packet #13 |

| | | |
|---|---|---|
| IKEv2 Header | Other fields are same as the Common Packet #13 | |
| E Payload | Other fields are same as the Common Packet #13 | |
| N Payload | Other fields are same as the Common Packet #13 | |
| N Payload | Other fields are same as the Common Packet #13 | |
| SA Payload | Same as Packet #3 | |
| Ni, Nr Payload | Other fields are same as the Common Packet #13 | |
| | Next Payload | 34 (KE) |
| KEi Payload | Other fields are same as the Packet #3 | |
| | DH Group # | 2 |
| | Key Exchange Data | DH#2 public key value |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs. The CREATE_CHILD_SA contains a D-H Group transform to use D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 14 (D-H Group 14) as DH Group # field and the Key Exchage Data. It is possible to use D-H Group 24 instead of D-H Group 14.
6. Observe the messages transmitted on Link A.
7. After reception of CREATE_CHILD_SA response indicating INVALID_KE_PAYLOAD from the NUT, TN1 retransmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs. The CREATE_CHILD_SA request contains a D-H Group transform to use D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 2 (D-H Group 2) as DH Group # field and the Key Exchage Data. It is possible to use D-H Group 24 instead of D-H Group 14.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type INVALID_KE_PAYLOAD which contains 2 (D-H Group 2) as Notification Data.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.8: Sending INVALID_KE_PAYLOAD in Initial Exchange

**Purpose:**

To verify an IKEv2 device properly handles KE payload which has different D-H Group # from accepted D-H Group #.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#2), Ni)
     |                | (Packet #2)
     |--------------->| IKE_SA_INIT response (HDR, SAr1(DH#2), KEr(DH#2), Nr)
     |                | (Judgment #2)
     |                |
     V                V

It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See Common packet #1 |

Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Same as the Common Packet #1 | |
| SA Payload | Other fields are same as the common packet #1 | |
| | SA Proposals | See SA Table below |
| KEi Payload | Other fields are same as the common packet #1 | |
| | DH Group # | 14 |
| | Key Exchange Data | DH#14 public key value |
| Ni, Nr Payload | Same as the Common Packet #1 | |

SA Payloads

| | | | |
|---|---|---|---|
| SA Proposal | Next Payload | | 0 (last) |
| | Reserved | | 0 |
| | Proposal Length | | 48 |
| | Proposal # | | 1 |
| | Protocol ID | | 1 (IKE) |
| | SPI Size | | 0 |
| | # of Transforms | | 5 |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 1 (ENCR) |
| | | Reserved | 0 |
| | | Transform ID | 3 (3DES) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 2 (PRF) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 3 (INTEG) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1_96) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 2 (1024 MODP Group) |
| | SA Transform | Next Payload | 0 (last) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 14 (2048 MODP Group) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload which contains a D-H Group transform proposes using D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 14 (D-H Group 14) as DH Group # field and the Key Exchange Data. It is possible to use D-H Group 24 instead of D-H Group 14.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request including KE payload with D-H Group 2 public key value to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD which contains 2 (D-H Group 2) as Notification Data. The message’s IKE_SA Responder’s SPI value is set to zero.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.6.9: Creating an IKE_SA without a CHILD_SA

**Purpose:**

To verify that an IKEv2 device can handles a failure of creating a CHILD_SA during the IKE_AUTH exchange.

**References:**

- [RFC 4718] - Sections 4.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<--------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                |  (Packet #1)
     |-------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                |  (Judgment #1)
     |                |
     |<--------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                |  (Packet #2)
     |-------------->|  IKE_AUTH response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
     |                |  (Judgment #2)
     |                |
     |<--------------|  INFORMATIONAL request (HDR, SK {})
     |                |  (Packet #3)
     |-------------->|  INFORMATIONAL response (HDR, SK {})
     |                |  (Judgment #3)
     |                |
     V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #17 |

Packet #2: IKE_AUTH request

Packet #2 is same as Common Packet #3 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |

| | | | |
|---|---|---|---|
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request with unacceptable SA proposal for the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with no payloads.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including a Notify type of NO_PROPOSAL_CHOSEN.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

## Group 1.7. Traffic Selector Negotiation

### Test IKEv2.EN.R.1.1.7.1: Narrowing Traffic Selectors

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 | TCP | ANY | NUT | TCP | ANY |
| **Outbound** | NUT | TCP | ANY | TN1 | TCP | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)    (End-Node)
    |                |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<--------------| IPsec {TCP SYN}
    |                | (Packet #3)
    |-------------->| IPsec {TCP RST}
    |                | (Judgment #3)
    |                |
    |<--------------| IPsec {ICMPv6 Echo Request}
    |                | (Packet #4)
    |-------X        | IPsec {ICMPv6 Echo Reply}
    |                | (Judgment #4)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #19 |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |

| | | | |
|---|---|---|---|
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- Packet #3: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The cryptographic checksum of the entire message |
| TCP Header | Source Port | 500 |
| | Destination Port | 500 |
| | Flags | SYN (0x02) |

*Part A (BASIC)*

1. TN1 sends an IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 sends an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port on NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. The Traffic Selector is narrowed to allow only TCP (6) as IP Protocol.

**Step 6: Judgment #3**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT never transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

### Test IKEv2.EN.R.1.1.7.2: TS_UNACCEPTABLE

**Purpose:**

To verify an IKEv2 device properly handles the Traffice Selector.

**References:**

- [RFC 4306] - Sections 2.8 and 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 | TCP | ANY | NUT | TCP | ANY |
| **Outbound** | NUT | TCP | ANY | TN1 | TCP | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    |<--------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, KEi, TSi, TSr})
    |               | (Packet #3)
    |-------------->| CREATE_CHILD_SA response (HDR, SK {N(TS_UNACCEPTABLE)})
    |               | (Judgment #3)
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #7 | |
| UDP Header | Same as the Common Packet #7 | |
| IKEv2 Header | Same as the Common Packet #7 | |
| E Payload | Same as the Common Packet #7 | |
| N Payload | Same as the Common Packet #7 | |
| SA Payload | Same as the Common Packet #7 | |
| Ni, Nr Payload | Same as the Common Packet #7 | |
| TSi Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

*Part A (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request including ICMPv6 (58) as IP Protocol ID value in Traffic Selector Payload to create new CHILD_SA.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type TS_UNACCEPTABLE.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.7.3: Narrowing Traffic Selectors from multiple Traffic Selector

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.8
- [RFC4718] - Section 4.10

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 | TCP | ANY | NUT | TCP | ANY |
| **Outbound** | NUT | TCP | ANY | TN1 | TCP | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                 TN1
(End-Node)      (End-Node)
    |                  |
    |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Packet #1)
    |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Judgment #1)
    |                  |
    |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Packet #2)
    |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    |<-----------------| IPsec {TCP SYN}
    |                  | (Packet #3)
    |----------------->| IPsec {TCP RST}
    |                  | (Judgment #3)
    |                  |
    |<-----------------| IPsec {ICMPv6 Echo Request}
    |                  | (Packet #4)
    |-------X          | IPsec {ICMPv6 Echo Reply}
    |                  | (Judgment #4)
    |                  |
    V                  V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #19 |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- Packet #3: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The cryptographic checksum of the entire message |
| TCP Header | Source Port | 500 |
| | Destination Port | 500 |
| | Flags | SYN (0x02) |

*Part A (BASIC)*

1. TN1 sends an IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 sends an IKE_AUTH request to the NUT. The message includes two Traffice Selectors. One is set to 6 (TCP) as IP Protocol. Another is set to 58 (IPV6-ICMP).
4. Observe the messages transmitted on Link A.
5. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port on NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. The Traffic Selector Payload has one Traffic Selector with IP Protocol 6 (TCP) to narrow the proposed Traffic Selectors.

**Step 6: Judgment #3**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT never transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Group 1.8. Error Handling

### Test IKEv2.EN.R.1.1.8.1: INVALID_IKE_SPI

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.1.8.2: INVALID_SYNTAX

This test case was deleted at revision 1.1.0.

### Test IKEv2.EN.R.1.1.8.3: INVALID_SELECTORS

This test case was deleted at revision 1.1.0.

## Group 1.10. Authentication of the IKE_SA

### Test IKEv2.EN.R.1.1.10.1: Sending Certificate Payload

**Purpose:**

To verify an IKEv2 device handles a CERTREQ payload and transmits a CERT payload propoerly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Local | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | NUT's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | nut.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | nut@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, CERT, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

- Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #3 |

| | | |
|---|---|---|
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Next Payload | 38 (CERTREQ) |
| | Oter fields are same as the Common Packet #3 | |
| CERTREQ Payload | See below | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Same as the Common Packet #3 | |
| TSr Payload | Same as the Common Packet #3 | |

| | | |
|---|---|---|
| CERTREQ Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Authority | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
8. Observe the messages transmitted on Link A.

*Part A: ID_RFC822_ADDR (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_IPV6_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

*Part B*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_FQDN and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

*Part B*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_RFC822_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.10.2: Sending Certificate Request Payload

**Purpose:**

To verify an IKEv2 device properly transmits CERTREQ payload.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
(End-Node)        (End-Node)
    |                   |
    |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                   | (Packet #1)
    |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
    |                   | (Judgment #1)
    |                   |
    V                   V
```

| Packet #1 | See Common Packet #1 |
|---|---|

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part B*

**Step 4: Judgment #1**

The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part C*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.10.3: RSA Digital Signature

**Purpose:**

To verify an IKEv2 device authenticates the corresponding node by RSA Digital Signature.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
    |                 | (Judgment #1)
    |                 |
    |<----------------| IKE_AUTH request (HDR, SK {IDi, CERT, AUTH, N, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    |                 |
    |<----------------| IPsec {Echo Request}
    |                 | (Packet #3)
    |---------------->| IPsec {Echo Reply}
    |                 | (Judgment #3)
    V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Next Payload | 37 (CERT) |
| | Oter fields are same as the Common Packet #3 | |
| CERT Payload | See below | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Same as the Common Packet #3 | |
| TSr Payload | Same as the Common Packet #3 | |

| | | |
|---|---|---|
| CERT Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate - Signature) |
| | Certificate Data | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
12. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.10.4: HEX string PSK

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key.

**References:**

- [RFC 4306] - Sections 2.15

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | Authentication Key Value |
|---|---|
| **Local** | 0xabadcafeabadcafeabadcafeabadcafe (128 bit binary string) |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                TN1
(End-Node)        (End-Node)
    |                  |
    |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Packet #1)
    |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Judgment #1)
    |                  |
    |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Packet #2)
    |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    V                  V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

# Group 1.11 Invalid Values

## Test IKEv2.EN.R.1.1.11.1: Non zero RESERVED fields in IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

# Test IKEv2.EN.R.1.1.11.2: Non zero RESERVED fields in IKE_AUTH request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.11.3: Version bit is set

**Purpose:**

To verify an IKEv2 device ignores the content of Version bit in IKE messages.

**References:**

- [RFC 4306] - Sections 3.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>Version bit is set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request whose Version bit is set to one.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.11.4: Response bit is set

**Purpose:**

To verify an IKEv2 device ignores an IKE request message whose Response bit is set.

**References:**

- [RFC 4306] - Sections 2.21

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |-------X         | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>Response bit is set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request whose Response bit is set to one.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT never responds with an IKE_SA_INIT response to an IKE_SA_INIT request from the TN1.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.1.1.11.5: Unrecognized Notify Message Type

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type in IKE messages.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr, N+})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #3)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #3)
     V                V

N: USE_TRANSPORT_MODE
N+: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #3 |
| UDP Header | All fields are same as Common Packet #3 |
| IKEv2 Header | All fields are same as Common Packet #3 |
| E Payload | All fields are same as Common Packet #3 |
| IDi Payload | All fields are same as Common Packet #3 |
| AUTH Payload | All fields are same as Common Packet #3 |
| N Payload | All fields are same as Common Packet #3 |

| | | |
|---|---|---|
| SA Payload | All fields are same as Common Packet #3 | |
| TSi Payload | All fields are same as Common Packet #3 | |
| TSr Paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #3 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | See each part description. |

*Part A: Unrecognized Notify Message Type of error 16383 (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request with a Notify payload of unrecognized Notify Message Type value (16383) to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.

*Part B: Unrecognized Notify Message Type of status 65535 (BASIC)*

7. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request with a Notify payload of unrecognized Notify Message Type value (65535) to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

# Group 2. The CREATE_CHILD_SA Exchange

## Group 2.1. Header and Payload Formats

### Test IKEv2.EN.R.1.2.1.1: Receipt of CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device transmits a CREATE_CHILD_SA response using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.3 and 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT               TN1
 (End-Node)        (End-Node)
     |                 |
     |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                 | (Packet #1)
     |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                 | (Judgment #1)
     |                 |
     |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                 | (Packet #2)
     |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                 | (Judgment #2)
     |                 |
     |<----------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                 | (Packet #3)
     |---------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                 | (Judgment #3)
     |                 |
     V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #13 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
6. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
12. Observe the messages transmitted on Link A.

*Part D: Notify Payload (USE_TRANSPORT_MODE) Format (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
18. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
24. Observe the messages transmitted on Link A.

*Part F: Nonce Payload Format (BASIC)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
28. Observe the messages transmitted on Link A.
29. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
30. Observe the messages transmitted on Link A.

*Part G: TSi Payload Format (BASIC)*

31. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
32. Observe the messages transmitted on Link A.

33. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
34. Observe the messages transmitted on Link A.
35. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
36. Observe the messages transmitted on Link A.

*Part H: TSr Payload Format (BASIC)*

37. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
38. Observe the messages transmitted on Link A.
39. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
40. Observe the messages transmitted on Link A.
41. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
42. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 70 Header format**

- An IKE_SA Initiator’s SPI field is set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field is set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field is set to Encrypted Payload (46).

- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to CREATE_CHILD_SA (36).
- A Flags field is set to $(00000100)_2 = (4)_{10}$.
- A Message ID field is set to the same value as corresponding IKEv2 request message's Message ID.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 71 Encrypted payload**

- A Next Payload field is set to N Payload (41).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire

message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 72 Notify Payload format**

- A Next Payload field is set to SA Payload (33).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload. It is 8 bytes for USE_TRANSPORT_MODE.
- A Protocol ID field is set to undefined (0).
- A SPI Size field is set to zero.
- A Notify Message Type field is set to USE_TRANSPORT_MODE (16391)

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**

```
                        1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
   ! Next     44    !0!      0      ! Length           40           !             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
   !       0        !        0      ! Length           36           !  |          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
   ! Number     1   ! Prot ID    3  ! SPI Size   4  ! Trans Cnt  3  !  |          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
   ! SPI value                                                      !  |          |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          |  !       3        !        0      ! Length            8           !  |          |
Transform |  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |SA Payload
          |  ! Type  1  (EN) !        0      ! Transform ID      3      (3DES) !  | Proposal |
       --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          |  !       3        !        0      ! Length            8           !  |          |
Transform |  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          |  ! Type  3  (IN) !        0      ! Transform ID      2      (SHA1) !  |          |
       --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          |  !       0        !        0      ! Length            8           !  |          |
Transform |  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
          |  ! Type  5  (ESN)!        0      ! Transform ID      0        (No) !  |          |
       --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 73 SA Payload contents**

The NUT transmits a CREATE_CHILD_SA response including properly formatted SA Payload containing following values (refer following figures):

```
                        1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ! Next Payload  !C!  RESERVED   !         Payload Length        !
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   !                                                               !
   ~                          <Proposals>                          ~
   !                                                               !
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 74 SA Payload format**

- A Next Payload field is set to Nr Payload (40).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.

The following proposal must be included in Proposals field.

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 75 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field is set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field is set to zero.
- A Proposal Length field is set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field is set to 1.
- A Protocol ID field is set to ESP (3).
- A SPI Size field is set to 4.
- A # of Transforms field is set to 3.
- A SPI field is set to the sending entity's SPI (4 octets value)

Transform field is set to following (There are 3 Transform Structures).

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 76 Transform sub-structure format**

Transform #1

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field is set to ENCR (1).
- A RESERVED field is set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.

- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field is set to INTEG (3).
- A RESERVED field is set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field is set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field is set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field is set to ESN (5).
- A RESERVED field is set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part E*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 30: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 77 Nonce Payload format**

- A Next Payload field is set to TSi Payload (44).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Nonce Data field is set to random data generated by the transmitting entity.
- The size of the Nonce must between 16 and 256 octets.

*Part F*

**Step 32: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 34: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 36: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 78 TSi Payload format**

- A Next Payload field is set to TSr Payload (45).
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to 1.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 79 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header.

- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to TN1 address.
- A Ending Address field is set to TN1 address.

*Part G*

**Step 38: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 40: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 42: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 80 TSr Payload format**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length of the current payload.
- A Number of TSs field is set to 1.
- A RESERVED field is set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 81 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field is set to zero.
- A Selector Length field is set to length of this Traffic Selector Substructure including the header.
- A Start Port field is set to zero.
- An End Port field is set to 65535.
- A Starting Address field is set to NUT address.
- An Ending Address field is set to NUT address.

**Possible Problems:**

- CREATE_CHILD_SA response has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, Nr, [KEr], TSi, TSr,
[N(ADDITIONAL_TS_POSSIBLE)]
```

- Each of transforms can be located in the any order.

## Group 2.2. Use of Retransmission Timers

### Test IKEv2.EN.R.1.2.2.1: Receipt of retransmitted CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device retransmits CREATE_CHILD_SA request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N, N+, SA, Nr, TSi, TSr})
    |                | (Judgment #3)
    |                |
    |                * wait until retrans timer expires
    |-------X        | CREATE_CHILD_SA response (HDR, SK {N, N+, SA, Nr, TSi, TSr})
    |                | (Judgment #4)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N, N+, SA, Nr, TSi, TSr})
    |                | (Judgment #5)
    |                |
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #13 |
| Packet #4 | See Common Packet #13 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to rekey the established CHILD_SAs to the NUT.
6. Observe the messages transmitted on Link A.
7. Observe the messages transmitted on Link A.
8. TN1 retransmits the same message as a CREATE_CHILD_SA request transmitted in Step 5 to the NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #4**
The NUT never retransmits a CREATE_CHILD_SA response which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Step 9: Judgment #5**
The NUT retransmits a CREATE_CHILD_SA response which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- none

# Group 2.3. State Synchronization and Connection Timeouts

## Test IKEv2.EN.R.1.2.3.1: Receiving Delete Payload for Multiple CHILD_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when CHILD_SAs are deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    |<--------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
    |                 | (Packet #3)
    |-------------->| CREATE_CHILD_SA response (HDR, SK {N, SA, Nr, TSi, TSr})
    |                 | (Judgment #3)
    |                 |
    |<--------------| INFORMATIONAL request (HDR, SK {D})
    |                 | (Packet #4)
    |-------------->| INFORMATIONAL request (HDR, SK {D})
    |                 | (Judgment #4)
    |                 |
    V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common below |
| Packet #3 | See Common below |
| Packet #4 | See Common below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #3 | |
| UDP Header | Same as the Common Packet #3 | |
| IKEv2 Header | Same as the Common Packet #3 | |
| E Payload | Same as the Common Packet #3 | |
| IDi Payload | Same as the Common Packet #3 | |
| AUTH Payload | Same as the Common Packet #3 | |
| N Payload | Same as the Common Packet #3 | |
| SA Payload | Same as the Common Packet #3 | |
| TSi Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #7 | |
| UDP Header | Same as the Common Packet #7 | |
| IKEv2 Header | Same as the Common Packet #7 | |
| E Payload | Same as the Common Packet #7 | |
| N Payload | Same as the Common Packet #7 | |
| SA Payload | Same as the Common Packet #7 | |
| Ni, Nr Payload | Same as the Common Packet #7 | |
| TSi Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |

| | | | |
|---|---|---|---|
| | | Ending Address | NUT's Global Address on Link A |

- Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | | Same as the Common Packet #17 |
| UDP Header | | Same as the Common Packet #17 |
| IKEv2 Header | | Same as the Common Packet #17 |
| E Payload | | Other fields are same as the Common Packet #17 |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 2 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |
| | | SPI negotiated by CREATE_CHILD_SA exchange |

*Part A: (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to establish a new CHILD_SA to the NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an INFORMATIONAL request with a Delete payload including the first negotiated CHILD_SA's inbound SPI and the second negotiated CHILD_SA's inbound SPI.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 8: Judgment #4**
The NUT transmits an INFORMATIONAL response with delete payload for SPIs which are negotiated by Initial Exchange and CREATE_CHILD_SA exchange.

**Possible Problems:**

- INFORMATIONAL response from NUT may not contain Delete Payload by implementation policy. This behavior is defined at section 1.4 in RFC 4306 as an exception.

# Group 2.4. Cryptographic Algorithm Negotiation

## Test IKEv2.EN.R.1.2.4.1: Sending NO_PROPOSAL_CHOSEN

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 2.7 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT                 TN1
(End-Node)          (End-Node)
     |                   |
     |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                   | (Packet #1)
     |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                   | (Judgment #1)
     |                   |
     |<------------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                   | (Packet #2)
     |------------------>| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                   | (Judgment #2)
     |                   |
     |<------------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                   | (Packet #3)
     |--------X          | CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                   |   or
     |------------------>| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
     |                   | (Judgment #3)
     |                   |
     V                   V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #13 | |
| UDP Header | Same as the Common Packet #13 | |
| IKEv2 Header | Same as the Common Packet #13 | |
| E Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| SA Payload | Other fields are same as the Common Packet #13 | |
| | SA Proposals | See below |
| Ni, Nr Payload | Same as the Common Packet #13 | |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 36 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 3 |
| | | SPI | | any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 12 (AES_CBC) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 5 (AES_XCBC_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 1 (ESN) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to rekey the established CHILD_SAs to the NUT. The CREATE_CHILD_SA request includes a SA payload with a proposal unaccepted by the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT does not transmit a CREATE_CHILD_SA response or transmits a CREATE_CHILD_SA response including a Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None.

## Group 2.5. Rekeying CHILD_SA Using a CREATE_CHILD_SA exchange

### Test IKEv2.EN.R.1.2.5.1: Close the replaced CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to rekey CHILD_SA and INFORMATIONAL Excahnges to delete old CHILD_SAs.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #5)
    |--------------->| INFORMATIONAL response (HDR, SK {D})
    |                | (Judgment #5)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #13 |
| Packet #5 | See below |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request including a Delete payload with the old CHILD_SA's SPI value to the NUT.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response including a Delete payload with the old CHILD_SA's SPI value to the TN1.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.5.2: Use of the new CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handle old CHILD_SA and new CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
     |               |
     |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |               | (Packet #1)
     |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |               | (Judgment #1)
     |               |
     |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |               | (Packet #2)
     |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |               | (Judgment #2)
     |               |
     |<--------------| IPsec {Echo Request}
     |               | (Packet #3)
     |-------------->| IPsec {Echo Reply}
     |               | (Judgment #3)
     |               |
     |<--------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |               | (Packet #4)
     |-------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |               | (Judgment #4)
     |               |
     |<--------------| INFORMATIONAL request (HDR, SK {D})
     |               | (Packet #5)
     |-------------->| INFORMATIONAL response (HDR, SK {D})
     |               | (Judgment #5)
     |               |
     |<--------------| IPsec {Echo Request} (new SA)
     |               | (Packet #6)
     |-------------->| IPsec {Echo Reply} (new SA)
     |               | (Judgment #6)
     V               V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19<br>(CHILD_SA is negotiated by steps 1 through 4.) |
| Packet #4 | See Common Packet #13 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #19<br>(CHILD_SA is negotiated by steps 7 through 8.) |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | | Same as the Common Packet #17 |
| UDP Header | | Same as the Common Packet #17 |
| IKEv2 Header | | Same as the Common Packet #17 |
| E Payload | | Other fields are same as the Common Packet #17 |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request including a Delete payload with the old CHILD_SA's SPI value to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response including a Delete payload with the old CHILD_SA's SPI value to the TN1.

**Step 12: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using the newly negotiated algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.5.3: Receiving Multiple Transform

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                | (Packet #3)
     |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                | (Judgment #3)
     V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

From part A to part C, TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the transforms as follows:

| | CREATE_CHILD_SA exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |

| | | | |
|---|---|---|---|
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #13 | |
| UDP Header | Same as the Common Packet #13 | |
| IKEv2 Header | Same as the Common Packet #13 | |
| E Payload | Same as the Common Packet #13 | |
| IDi Payload | Same as the Common Packet #13 | |
| AUTH Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| SA Payload | Other fields are same as the Common Packet #13 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA’s SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA’s SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA’s SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.5.4: Receiving Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |                | (Judgment #3)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the two proposals as follows:

| | CREATE_CHILD_SA exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | **ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |

| | | | | | |
|---|---|---|---|---|---|
| **Part B** | Proposal #1 | ESP | ENCR_3DES | **AUTH_AES_XCBC_96** | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part C** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | **ESN** |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #13 | |
| UDP Header | Same as the Common Packet #13 | |
| IKEv2 Header | Same as the Common Packet #13 | |
| E Payload | Same as the Common Packet #13 | |
| IDi Payload | Same as the Common Packet #13 | |
| AUTH Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| SA Payload | Other fields are same as the Common Packet #13 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 2 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |

| | | | | |
|---|---|---|---|---|
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.5.5: Perfect Forward Secrecy

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA exchange when Perfect Forward Secrecy enabels.

**References:**

- [RFC 4306] - Sections 2.12

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. Enable PFS.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT               TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, KEi, TSi, TSr})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, KEr, TSi, TSr})
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #5)
    |--------------->| INFORMATIONAL response (HDR, SK {D})
    |                | (Judgment #5)
    |                |
    |<---------------| IPsec {Echo Request} (new SA)
    |                | (Packet #6)
    |--------------->| IPsec {Echo Reply} (new SA)
    |                | (Judgment #6)
    V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19<br>(CHILD_SA is negotiated by steps 1 through 4.) |
| Packet #4 | See below |
| Packet #5 | See below |
| Packet #6 | See Common Packet #19<br>(CHILD_SA is negotiated by steps 7 through 8.) |

Packet #4: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #13 | |
| UDP Header | Same as the Common Packet #13 | |
| IKEv2 Header | Same as the Common Packet #13 | |
| E Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| N Payload | Same as the Common Packet #13 | |
| SA Payload | Same as the Common Packet #13 | |
| Ni Payload | Next Payload | 34 (KE) |
| KEi Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Key Exchange Data | any |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request including a Delete payload with the old CHILD_SA's SPI value to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an Echo Request with IPsec ESP using the second negotiated algorithms to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response including a Delete payload with the old CHILD_SA's SPI value to the TN1.

**Step 12: Judgment #6**
The NUT transmits an Echo Reply with IPsec ESP using the newly negotiated algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.5.6: Use of the old CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handle old CHILD_SA and new CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #3)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #3)
     |                |
     |<---------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
     |                | (Packet #4)
     |--------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
     |                | (Judgment #4)
     |                |
     |<---------------| IPsec {Echo Request} (old CHILD_SA)
     |                | (Packet #5)
     |--------------->| IPsec {Echo Reply} (old CHILD_SA or new CHILD_SA)
     |                | (Judgment #5)
     V                V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19<br>(CHILD SA is negotiated by steps 1 through 4.) |

| | |
|---|---|
| Packet #4 | See Common Packet #13 |
| Packet #5 | See Common Packet #19<br>(CHILD_SA is negotiated by steps 1 through 4.) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms again.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 10: Judgment #5**
The NUT transmits an Echo Reply with IPsec ESP. The NUT can use both the first CHILD_SA and the new CHILD_SA.

**Possible Problems:**

- none

# Group 2.6. Rekeying IKE_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.EN.R.1.2.6.1: Sending CREATE_CHILD_SA response

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA Excahnge to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8 and 2.18

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #3)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #3)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                | (Packet #4)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
    |                | (Judgment #4)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |

| Packet #4 | See Common Packet #11 |
|---|---|

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA's initiator's SPI value.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's responder's SPI value in the SPI field.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.EN.R.1.2.6.2: Receipt of cryptographically valid message on the old SA

**Purpose:**

To verify an IKEv2 device properly uses old IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)      (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #3)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #3)
     |                |
     |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                | (Packet #4)
     |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                | (Judgment #4)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK {}) (old IKE_SA)
     |                | (Packet #5)
     |--------------->| INFORMATIONAL response (HDR, SK {}) (old IKE_SA)
     |                | (Judgment #5)
     V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |

| | |
|---|---|
| Packet #4 | See Common Packet #11 |
| Packet #5 | See Common Packet #17<br>(CHILD_SA is negotiated by steps 1 through 4.) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request with no payloads protected by the old IKE_SA.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's responder's SPI value in the SPI field.

**Step 10: Judgment #5**
The NUT responds with an INFORMATIONAL response with no payloads protected by the old IKE_SA.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.6.3: Receipt of cryptographically valid message on the new SA

**Purpose:**

To verify an IKEv2 device properly uses new IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Judgment #2)
    |               |
    |<--------------| IPsec {Echo Request}
    |               | (Packet #3)
    |-------------->| IPsec {Echo Reply}
    |               | (Judgment #3)
    |               |
    |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |               | (Packet #4)
    |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
    |               | (Judgment #4)
    |               |
    |<--------------| INFORMATIONAL request (HDR, SK {})
    |               | (Packet #5)
    |-------------->| INFORMATIONAL response (HDR, SK {})
    |               | (Judgment #5)
    V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |

| | |
|---|---|
| Packet #4 | See Common Packet #11 |
| Packet #5 | See Common Packet #17 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's responder's SPI value in the SPI field.

**Step 10: Judgment #5**
The NUT responds with an INFORMATIONAL response with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.6.4: Close the replaced IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.8 and 5.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT             TN1
(End-Node)      (End-Node)
     |               |
     |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |               | (Packet #1)
     |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |               | (Judgment #1)
     |               |
     |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |               | (Packet #2)
     |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |               | (Judgment #2)
     |               |
     |<--------------| IPsec {Echo Request}
     |               | (Packet #3)
     |-------------->| IPsec {Echo Reply}
     |               | (Judgment #3)
     |               |
     |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |               | (Packet #4)
     |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |               | (Judgment #4)
     |               |
     |<--------------| INFORMATIONAL request (HDR, SK {D})
     |               | (Packet #5)
     |-------------->| INFORMATIONAL response (HDR, SK {})
     |               | (Judgment #5)
     |               |
     |<--------------| IPsec {Echo Request}
     |               | (Packet #6)
     |-------------->| IPsec {Echo Reply}
     |               | (Judgment #6)
     V               V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #11 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #19 |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index(es) (SPI) | empty |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA to the NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request with a Delete payload which has 1 (IKE_SA) in the Protocol ID field, zero in the SPI Size field and zero in the # of SPIs field.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's responder's SPI value in the SPI field.

**Step 10: Judgment #5**
The NUT responds with an INFORMATIONAL response with no payloads.

**Step 12: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.

**Possible Problems:**

- none.

## Test IKEv2.EN.R.1.2.6.5: Receiving Multiple Transform

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transform to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)      (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr })
    |                | (Judgment #3)
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the transforms as follows:

| | **IKE_SA_INIT exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_AES_CBC**<br>**ENCR_3DES** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_AES128_CBC**<br>**PRF_HMAC_SHA1** | AUTH_HMAC_SHA1_96 | Group 2 |

| | | | | |
|---|---|---|---|---|
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96**<br>**AUTH_HMAC_SHA1_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or**<br>**Group 24,**<br>**Group 2** |

- Packet #3 CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #11 | |
| UDP Header | Same as the Common Packet #11 | |
| IKEv2 Header | Same as the Common Packet #11 | |
| SA Payload | Other fields are same as the common packet #11 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Same as the Common Packet #11 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type

REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo Random Function (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithm (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Group (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2"as proposed algorithms.

*Part B*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.6.6: Receiving Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple proposal to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
    |                 | (Packet #3)
    |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
    |                 | (Judgment #3)
    V                 V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the two proposals as follows:

| | IKE_SA_INIT exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | Proposals | Protocol ID | Encryption | PRF | Integrity | D-H Group |
| Part A | Proposal #1 | IKE | ENCR_AES_CBC | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Part B** | Proposal #1 | IKE | ENCR_3DES | **PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96** | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part D** | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or Group 24** |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #11 | |
| UDP Header | Same as the Common Packet #11 | |
| IKEv2 Header | Same as the Common Packet #11 | |
| SA Payload | Other fields are same as the common packet #11 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Same as the Common Packet #11 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 2 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |

| | | | | |
|---|---|---|---|---|
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo Rnadom Function (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Group (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.

23. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.6.7: Changing PRFs when rekeying the IKE_SA

**Purpose:**

To verify an IKEv2 device properly uses new IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  Configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_SA Rekeying Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | ***PRF_AES128_XCBC*** | AUTH_HMAC_SHA1_96 | Group 2 |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                | (Packet #3)
     |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
     |                | (Judgment #3)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK {})
     |                | (Packet #4)
     |--------------->| INFORMATIONAL response (HDR, SK {})
     |                | (Judgment #4)
     V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | Seebelow |
| Packet #4 | See Common Packet #17 |

Packet #3: CREATE_CHILD_SA request

Packet #3 is same as Common Packet #11 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type PRF is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (PRF_AES128_XCBC) |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to the NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an INFORMATIONAL request with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's responder's SPI value in the SPI field.

**Step 8: Judgment #4**

The NUT responds with an INFORMATIONAL response with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.

**Possible Problems:**

- none

## Test IKEv2.EN.R.1.2.6.8: D-H transform NONE when rekeying the IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.EN.R.1.2.6.9: Rekeying Failure

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KE})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
    |                | (Judgment #3)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #13 |
| UDP Header | Same as the Common Packet #13 |
| IKEv2 Header | Same as the Common Packet #13 |
| E Payload | Same as the Common Packet #13 |
| N Payload | Same as the Common Packet #13 |
| N Payload | Same as the Common Packet #13 |

| | | |
|---|---|---|
| SA Payload | Other fields are same as the Common Packet #13 | |
| | SA Proposals | See below |
| Ni, Nr Payload | Same as the Common Packet #13 | |
| TSi Payload | Same as the Common Packet #13 | |
| TSr Payload | Same as the Common Packet #13 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 36 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 3 |
| | | SPI | | any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 12 (AES_CBC) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 4 (AES128_XCBC_96) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 5 (AES_XCBC_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 1 (ESN) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to rekey the established IKE_SA to the NUT. The CREATE_CHILD_SA request includes a SA payload with a proposal unaccepted by the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None.

# Group 2.7. Creating new CHILD_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.EN.R.1.2.7.1: Receipt of cryptographically valid message on the new SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to create a new CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8 and 2.18

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| IPsec {TCP-SYN}
    |                | (Packet #3)
    |--------------->| IPsec {TCP-RST}
    |                | (Judgment #3)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #4)
    |-------X        | IPsec {Echo Reply}
    |                | (Judgment #4)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
    |                | (Packet #5)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {N, SA, Nr, TSi, TSr})
    |                | (Judgment #5)
    |                |
    |<---------------| IPsec {TCP-SYN}
    |                | (Packet #6)
    |--------------->| IPsec {TCP-RST}
    |                | (Judgment #6)
    |                |
    |<---------------| IPsec {Echo Request}
    |                | (Packet #7)
    |--------------->| IPsec {Echo Reply}
    |                | (Judgment #7)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #19 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See Common Packet #19 |

- Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #3 |
| UDP Header | Same as the Common Packet #3 |
| IKEv2 Header | Same as the Common Packet #3 |
| E Payload | Same as the Common Packet #3 |
| IDi Payload | Same as the Common Packet #3 |
| AUTH Payload | Same as the Common Packet #3 |
| N Payload | Same as the Common Packet #3 |
| SA Payload | Same as the Common Packet #3 |

| | | |
|---|---|---|
| TSi Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #3 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link A |
| | | Ending Address | TN1's Global Address on Link A |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link X |
| | | Ending Address | NUT's Global Address on Link X |

- Packet #3: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| TCP Header | Source Port | 30000 |
| | Destination Port | 30000 |
| | Flags | SYN (0x02) |

- Packet #5: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #7 | |
| UDP Header | Same as the Common Packet #7 | |
| IKEv2 Header | Same as the Common Packet #7 | |
| E Payload | Same as the Common Packet #7 | |
| IDi Payload | Same as the Common Packet #7 | |
| AUTH Payload | Same as the Common Packet #7 | |
| N Payload | Same as the Common Packet #7 | |
| SA Payload | Same as the Common Packet #7 | |
| TSi Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #7 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TN1's Global Address on Link X |
| | | Ending Address | TN1's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |

| | | | |
|---|---|---|---|
| | | IP Protocol ID | 58 (IPV6-ICMP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | NUT's Global Address on Link A |
| | | Ending Address | NUT's Global Address on Link A |

- Packet #6: TCP SYN packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 6 (TCP) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| TCP Header | Source Port | 30000 |
| | Destination Port | 30000 |
| | Flags | SYN (0x02) |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port 30000 on NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a TCP-SYN packet with IPsec ESP using corresponding algorithms to closed port 30000 on NUT.
12. Observe the messages transmitted on Link A.
13. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT never transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT transmits a TCP-RST packet with IPsec ESP using corresponding algorithms.

**Step 14: Judgment #7**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- If the NUT uses TCP port 30000 for other applications, the TN1 transmits TCP-SYN packets to other closed TCP port on the NUT.

## Group 2.8. Error Handling

### Test IKEv2.EN.R.1.2.8.1: AUTHENTICATION_FAILED

This test case was deleted at revision 1.1.0.

## Group 2.9. Non zero RESERVED fields

### Test IKEv2.EN.R.1.2.9.1: Non zero RESERVED fields in CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N+, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N+, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    |<----------------| CREATE_CHILD_SA request (HDR, SK {N, N+, SA, Ni, TSi, TSr})
    |                 | (Packet #3)
    |---------------->| CREATE_CHILD_SA response (HDR, SK {N+, SA, Nr, TSi, TSr})
    |                 | (Judgment #3)
    V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #13<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.

2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- none

# Group 3. The INFORMATIONAL Exchange

## Group 3.1. Header and Payload Formats

### Test IKEv2.EN.R.1.3.1.1: Sending INFORMATIONAL response

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.1.2, 1.4, 3.1 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| INFORMATIONAL request (HDR, SK { })
     |                | (Packet #3)
     |--------------->| INFORMATIONAL response (HDR, SK { })
     |                | (Judgment #3)
     |                |
     V                V

 N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #17 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.

2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT_SA response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT_SA response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 82 Header format**

- An IKE_SA Initiator’s SPI field is set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field is set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.

- A Next Payload field is set to Encrypted Payload (46).
- A Major Version field is set to 2.
- A Minor Version field is set to zero.
- An Exchange Type field is set to INFORMATIONAL (37).
- A Flags field is set to $(00000100)_2 = (4)_{10}$.
- A Message ID field is set to the same value as corresponding IKEv2 request message's Message ID.
- A Length field is set to the length of the message (header + payloads) in octets.

*Part B*

**Step 9: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 11: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 14: Judgment #3**

The NUT transmits an INFORMATIONAL response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 83 Encrypted payload**

- A Next Payload field is set to zero.
- A Critical field is set to zero.
- A RESERVED field is set to zero.
- A Payload Length field is set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field is set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field is set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field is set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field is set to the length of the Padding field.

- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

**Possible Problems:**

- None.

## Group 3.2. Use of Retransmission Timers

### Test IKEv2.EN.R.1.3.2.1: Receipt of retransmitted INFORMATIONAL request

**Purpose:**

To verify an IKEv2 device properly handles the retransmission.

**References:**

- [RFC 4306] - Sections 1.1.2, 1.4 and 2.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK { })
    |                | (Packet #3)
    |--------------->| INFORMATIONAL response (HDR, SK { })
    |                | (Judgment #3)
    |                |
    |                * wait until retrans timer expires
    |--------------->| INFORMATIONAL response (HDR, SK { })
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK { })
    |                | (Packet #4)
    |--------------->| INFORMATIONAL response (HDR, SK { })
    |                | (Judgment #5)
    |                |
    V                V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #17 |
| Packet #4 | See Common Packet #17<br>(same Message ID as packet #3) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with no payloads.
6. Observe the messages transmitted on Link A.
7. Observe the messages transmitted on Link A.
8. TN1 transmits an INFORMATIONAL request with no payloads. The Message ID is the same as step 5.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Step 7: Judgment #4**
The NUT never retransmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Step 9: Judgment #5**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- none

# Group 3.3. Non zero RESERVED fields

## Test IKEv2.EN.R.1.3.3.1: Non RESERVED fields in INFORMATIONAL request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                TN1
(End-Node)         (End-Node)
    |                  |
    |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Packet #1)
    |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Judgment #1)
    |                  |
    |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                  | (Packet #2)
    |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    |<-----------------| INFORMATIONAL request (HDR, SK {})
    |                  | (Packet #3)
    |----------------->| INFORMATIONAL response (HDR, SK {})
    |                  | (Judgment #3)
    |                  |
    V                  V

N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #17<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.

2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads. All RESERVED fields in the message are set to one.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

# Group 4. RFC 5996

## Group 4.1. Rekeying IKE SAs Using a CREATE_HLD_SA Exchange

### [EN.R.P29.L2503.ADD] Test IKEv2.EN.R.1.4.1.1.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 5996] - Section 2.18

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
 (End-Node)       (End-Node)
     |                |
     |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
     |                | (Packet #1)
     |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
     |                | (Judgment #1)
     |                |
     |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
     |                | (Packet #2)
     |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
     |                | (Judgment #2)
     |                |
     |<---------------| IPsec {Echo Request}
     |                | (Packet #3)
     |--------------->| IPsec {Echo Reply}
     |                | (Judgment #3)
     |                |
     |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
     |                | (Packet #4)
     |--------------->| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
     |                | (Judgment #4)
     |                |
     V                V
N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |

| | |
|---|---|
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #11 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.Observe the messages transmitted on Link A.
6. Observe the messages transmitted on Link A.
7. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA's initiator's SPI value. The proposal has the value "NONE" for the Diffie-Hellman transform.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response with Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None

## [EN.R.P86.L4030.ADD.1] Test IKEv2.EN.R.1.4.1.2.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a proposal that contains a Transform Type it does not understand

**References:**

- [RFC 5996] - Section 3.3.6

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1(P1, P2), KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1(P2)), KEr, Nr)
    |                | (Judgment #1)
    |                |
    V                V
P1: a proposal that contains 5 Transforms, "a Transform Type (240)",
    "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2"
P2: a proposal that contains 4 Transforms, "ENCR_3DES", "PRF_HMAC_SHA1",
    "AUTH_HMAC_SHA1_96", and "D-H Group 2"
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 2 SA Proposals. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 2 proposals. One proposal has 5 Transforms which are "a Transform Type (240)", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2". Another proposal has 4 Transforms which are "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [EN.R.P86.L4030.ADD.2] Test IKEv2.EN.R.1.4.1.3.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a proposal that is missing a mandatory Transform Type

**References:**

- [RFC 5996] - Section 3.3.6

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT               TN1
 (End-Node)        (End-Node)
     |                 |
     |<----------------| IKE_SA_INIT request (HDR, SAi1(P1, P2), KEi, Ni)
     |                 | (Packet #1)
     |---------------->| IKE_SA_INIT response (HDR, SAr1(P2), KEr, Nr)
     |                 | (Judgment #1)
     |                 |
     V                 V
P1: a proposal that contains 3 Transforms, "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96",
    and "D-H Group 2"
P2: a proposal that contains 4 Transforms, "ENCR_3DES", "PRF_HMAC_SHA1",
    "AUTH_HMAC_SHA1_96",  and "D-H Group 2"
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 2 SA Proposals. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 2 proposals. One proposal has 3 Transforms which "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2". Another proposal has 4 Transforms which are "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [EN.R.P86.L4034.ADD.1] Test IKEv2.EN.R.1.4.1.4.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a transform that it does not understand

**References:**

- [RFC 5996] - Section 3.3.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT               TN1
(End-Node)        (End-Node)
    |                 |
    |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 5 SA Transforms. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 5 Transforms which are "1 (ENCR) as Transform Type and 1023 as Transform ID", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [EN.R.P86.L4034.ADD.2] Test IKEv2.EN.R.1.4.1.5.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a Transform Attribute it does not understand

**References:**

- [RFC 5996] - Section 3.3.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                  TN1
(End-Node)          (End-Node)
    |                    |
    |<-------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                    | (Packet #1)
    |------------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                    | (Judgment #1)
    |                    |
    V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packt #1<br>IKE_SA_INIT request has 5 SA Transforms. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 5 Transforms which are "ENCR_3DES with Transform Attribute of type KeyLength and value 192", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2"
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [EN.R.P57.L2663.ADD] Test IKEv2.EN.R.1.4.1.6.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can notify AUTHENTICATION_FAILED

**References:**

- [RFC 5996] - Section 2.21.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response { N(AUTHENTICATION_FAILED) }
    |                | (Judgment #2)
    |                |
    V                V
N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3<br>Authentication Data is 0x0123456789abcdef0123456789abcdef01234567. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT. The response includes invalid Authentication Data 0x0123456789abcdef0123456789abcdef01234567.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including Notify payload of type AUTHENTICATION_FAILED.

**Possible Problems:**

- None

## [EN.R.P69.L3234.ADD] Test IKEv2.EN.R.1.4.1.7.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CHILD_CHILD_SA request to close a Child SA that it is currently rekeying.

**References:**

- [RFC 5996] - Section 2.25.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
   ...              ...
    |                |                  ---
    |<---------------| IPsec {Echo Request} |
    |                | (Packet #3)          |
    |--------------->| IPsec {Echo Reply}   | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)        |
    |                |                  ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {N(REKEY_SA), SA, Ni, TSi, TSr})
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #4)
    |--------------->| INFORMATIONAL response (HDR, SK {D})
    |                | (Judgment #5)
    |                |
    V                V
N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #1 |
|---|---|

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |

- Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.Observe the messages transmitted on Link A.
6. Observe the messages transmitted on Link A.
7. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protocol ID, 4 as SPI Size and SPI value to delete Child SA.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey a Child SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence

Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response. The response includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Possible Problems:**

- None

## [EN.R.P69.L3252.ADD] Test IKEv2.EN.R.1.4.1.8.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process INFORMATIONAL request to close IKE SA that it is currently rekeying.

**References:**

- [RFC 5996] - Section 2.25.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
   ...              ...
    |                |                  ---
    |<---------------| IPsec {Echo Request} |
    |                | (Packet #3)          |
    |--------------->| IPsec {Echo Reply}   | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)        |
    |                |                  ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #4)
    |--------------->| INFORMATIONAL response (HDR, SK {})
    |                | (Judgment #5)
    |                |
    |-------X        | CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
    |                | (Judgment #6)
    V                V
N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common below |

- Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index(es) (SPI) | empty |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.Observe the messages transmitted on Link A.
6. Observe the messages transmitted on Link A.
7. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 1 (IKE) as Protocol ID, zero as SPI Size and no SPI value.
10. Observe the messages transmitted on Link A.
11. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**

The NUT transmits a CREATE_CHILD_SA request to rekey IKE SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response with no payloads.

**Step 11: Judgment #6**
The NUT does not retransmit a CREATE_CHILD_SA request to rekey a Child SA.

**Possible Problems:**

- None

## [EN.R.P69.L3258.ADD] Test IKEv2.EN.R.1.4.1.9.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CREATE_CHILD_SA request to rekey a Child SA when it is currently rekeying the IKE SA.

**References:**

- [RFC 5996] - Section 2.5.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT             TN1
(End-Node)      (End-Node)
    |               |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |               | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |               | (Judgment #1)
    |               |
    |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |               | (Packet #2)
    |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |               | (Judgment #2)
    |               |
   ...             ...
    |               |                   ---
    |<--------------| IPsec {Echo Request} |
    |               | (Packet #3)          |
    |-------------->| IPsec {Echo Reply}   | repeat Echo exchange until lifetime of SA is expired
    |               | (Judgment #3)        |
    |               |                   ---
   ...             ...
    |               |
    |-------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
    |               | (Judgment #4)
    |               |
    |<--------------| CREATE_CHILD_SA request (HDR, SK {N(REKEY_SA), SA, Ni, TSi, TSr})
    |               | (Packet #4)
    |-------------->| CREATE_CHILD_SA response (HDR, SK {N(TEMPORARY_FAILURE)})
    |               | (Judgment #5)
    |               |
    V               V
N: USE_TRANSPORT_MODE
```

| Packet #1 | See Common Packet #1 |
|---|---|

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See Common Packet #11 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.Observe the messages transmitted on Link A.
6. Observe the messages transmitted on Link A.
7. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request to rekey a Child SA. The request includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request to rekey a Child SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response. The response includes a Notify payload of type TEMPORRAY_FAILURE.

**Possible Problems:**

- None

## [EN.R.P69.L3260.ADD] Test IKEv2.EN.R.1.4.1.10.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CREATE_CHILD_SA request to delete a Child SA when it is currently rekeying the IKE SA

**References:**

- [RFC 5996] - Section 2.5.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
   ...              ...
    |                |                 ---
    |<---------------| IPsec {Echo Request} |
    |                | (Packet #3)          |
    |--------------->| IPsec {Echo Reply}   | repeat Echo exchange until lifetime of SA is expired
    |                | (Judgment #3)        |
    |                |                 ---
   ...              ...
    |                |
    |--------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
    |                | (Judgment #4)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {D})
    |                | (Packet #4)
    |--------------->| INFORMATIONAL response (HDR, SK {D})
    |                | (Judgment #5)
    |                |
    V                V
N: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |

| | |
|---|---|
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #19 |
| Packet #4 | See below |

- Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.Observe the messages transmitted on Link A.
6. Observe the messages transmitted on Link A.
7. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
8. Observe the messages transmitted on Link A.
9. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 8: Judgment #4**
TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Step 10: Judgment #5**
The NUT transmits an INFORMATIONAL response with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Possible Problems:**

- None

## Section 1.2.2. Endpoint to Security Gateway Tunnel

## Group 1. The Initial Exchanges

# Group 1.1. Header and Payload Formats

## Test IKEv2.EN.R.2.1.1.1: Sending IKE_AUTH response

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH response using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
(End-Node)         (SGW)
    |                 |
    |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                 | (Packet #1)
    |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                 | (Judgment #1)
    |                 |
    |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                 | (Packet #2)
    |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                 | (Judgment #2)
    |                 |
    V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

*Part A: IKE Header Format (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (ADVANCED)*

5. TN1 transmits an IKE_SA_INIT request to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an IKE_SA_INIT request to NUT.

8. Observe the messages transmitted on Link A.

*Part C: IDr Payload Format (ADVANCED)*

9. TN1 transmits an IKE_SA_INIT request to NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an IKE_SA_INIT request to NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (ADVANCED)*

13. TN1 transmits an IKE_SA_INIT request to NUT.
14. Observe the messages transmitted on Link A.
15. TN1 transmits an IKE_SA_INIT request to NUT.
16. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (ADVANCED)*

17. TN1 transmits an IKE_SA_INIT request to NUT.
18. Observe the messages transmitted on Link A.
19. TN1 transmits an IKE_SA_INIT request to NUT.
20. Observe the messages transmitted on Link A.

*Part F: TSi Payload Format (ADVANCED)*

21. TN1 transmits an IKE_SA_INIT request to NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits an IKE_SA_INIT request to NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSr Payload Format (ADVANCED)*

25. TN1 transmits an IKE_SA_INIT request to NUT.
26. Observe the messages transmitted on Link A.
27. TN1 transmits an IKE_SA_INIT request to NUT.
28. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 84 Header format**

- An IKE_SA Initiator’s SPI field set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_AUTH (35).
- A Flags field set to (00010000)2 = (16)10.
- A Message ID field set to 1.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 85 Encrypted payload**

- A Next Payload field set to IDr Payload (36).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm.
- An Encrypted IKE Payloads field set to encrypted IKE Payloads
- A Padding field set to any value which to be a multiple of the encryption block size.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. The checksum must be valid.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 86 ID Payload format**

- A Next Payload field set to AUTH Payload (39).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- An ID Type field set to ID_IPV6_ADDR (5).
- A RESERVED field set to zero.
- An Identification Data field set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 87 AUTH Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- An Auth Method field set to Shared Key Message Integrity Code (2).
- A RESERVED field set to zero.
- An Authentication Data field set to correct authentication value.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

```
                               1                   2                   3
           0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
          ! Next    44    !0!     0       ! Length          40          !              |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
          !       0       !       0       ! Length          36          !  |           |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          ! Number    1   ! Prot ID   3   ! SPI Size  4   ! Trans Cnt  3 !  |           |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          ! SPI value                                                   !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       3       !       0       ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
        | ! Type  1  (EN) !       0       ! Transform ID     3    (3DES) !  | Proposal  |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       3       !       0       ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | ! Type  3  (IN) !       0       ! Transform ID     2    (SHA1) !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | !       0       !       0       ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        | ! Type  5  (ESN)!       0       ! Transform ID     0      (No)  !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 88 SA Payload contents**

The NUT transmits an IKE_AUTH response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 89 SA Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

A Proposals field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 90 Proposal sub-structure format**

- A 0 or 2 field set to zero (last).
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes.
- A Proposal # field set to 1.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity’s SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 91 Transform sub-structure format**

- A 0 or 3 field set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

- A 0 or 3 field set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute.
- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

- A 0 or 3 field set to zero.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 92 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 93 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to NUT address.
- A Ending Address field set to NUT address.

*Part G*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 94 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 95 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to TN1 address.
- An Ending Address field set to TN1 address.

**Possible Problems:**

- None.

## Test IKEv2.EN.R.2.1.1.2: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1               TH1
(End-Node)       (SGW)             (Host)
  |                |                 |
  |<---------------|                 | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                 | (Packet #1)
  |--------------->|                 | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                 | (Judgment #1)
  |                |                 |
  |<---------------|                 | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                 | (Packet #2)
  |--------------->|                 | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                 | (Judgment #2)
  |                |                 |
  |<===============+-----------------| IPsec {Echo Request}
  |                |                 | (Packet #3)
  |================+---------------->| IPsec {Echo Reply}
  |                |                 | (Judgment #3)
  |                |                 |
  v                v                 v
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #20 |

*Part A (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT response to NUT.
4. Observe the messages transmitted on Link A.
5. TH1 transmits an Echo Request and TN1 forwards an Echo Request with IPsec ESP using corresponding algorithms to NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

Section 2. Security Gateway
Section 2.1. Initiator
Section 2.1.1. Security Gateway to Security Gateway Tunnel
Group 1. The Initial Exchanges

# Group 1.1. Header and Payload Formats

## Test IKEv2.SGW.I.1.1.1.1: Sending IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device transmits IKE_SA_INIT request using properly Header and Payloads format

**References:**

- [RFC4306] - Section 1.2, 2.10, 3.1, 3.2, 3.3, 3.4 and 3.9
- [RFC 4718] - Sections 7.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Judgment #1)
  |               |
  V               V
```

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B: SA Payload Format (BASIC)*

3. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C: KE Payload Format (BASIC)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

*Part D: Nonce Payload Format (BASIC)*

7. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 96 Header format**

- An IKE_SA Initiator's SPI field set to a 64-bits value chosen by the NUT. It MUST not be zero.
- An IKE_SA Responder's SPI field set to zero.
- A Next Payload field set to SA Payload (33).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_SA_INIT (34).
- A Flags field set to (00010000)2 = (16)10.
- A Message ID field set to zero.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 4: Judgment #1**

```
                         1                   2                   3
           0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
          ! Next     34     !0!     0       ! Length          44           !              |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---           |
          !       0       !       0       ! Length          40           !  |           |
          +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
          ! Number     1   ! Prot ID    1   ! SPI Size   0   ! Trans Cnt   4  !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | !       3       !       0       ! Length          8            !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | ! Type  1  (EN) !       0       ! Transform ID     3      (3DES) !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | !       3       !       0       ! Length          8            !  |           |SA Payload
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |Proposal  |
         | ! Type  2  (PR) !       0       ! Transform ID     2      (SHA1) !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | !       3       !       0       ! Length          8            !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | ! Type  3  (IN) !       0       ! Transform ID     2      (SHA1) !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | !       0       !       0       ! Length          8            !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         | ! Type  4  (DH) !       0       ! Transform ID     2      (1024) !  |           |
      --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 97 SA Payload contents**

The NUT transmits an IKE_SA_INIT request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 98 SA Payload format**

- A Next Payload field set to KE Payload (34).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 99 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 40 bytes for this proposal according to Common Configuration.
- A Proposal # field set to 1 if this structure is the first proposal, otherwise set to 1 greater than the previous proposal.
- A Protocol ID field set to IKE (1).
- A SPI Size field set to zero.
- A # of Transforms field set to 4.

A Transform field set to following (There are 4 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 100 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.

- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for PRF_HMAC_SHA1.
- A Transform Type field set to PRF (2).
- A RESERVED field set to zero.
- A Transform ID set to PRF_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #4

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for 1024 MODP Group.
- A Transform Type field set to D-H (4).
- A RESERVED field set to zero.
- A Transform ID set to Group2 (2).

*Part C*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT request including properly formatted KE Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!          DH Group #           !           RESERVED            !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Key Exchange Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 101 KE Payload format**

- A Next Payload field set to Nonce Payload (40).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 136 bytes for Group 2.
- A DH Group field set to Group2 (2).
- A RESERVED field set to zero.
- A Key Exchange Data field set to Diffie-Hellman public value. The length of the Key Exchange Data field must be equal to 1024bit.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT request including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 102 Nonce Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Nonce Data field set to random data generated by the transmitting entity. The size of the Nonce must between 16 and 256 octets.

**Possible Problems:**

- IKE_SA_INIT request has following packet format. It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(COOKIE)],
SA, KE, Ni,
[N(NAT_DETECTION_SOURCE_IP)+,
 N(NAT_DETECTION_DESTINATION_IP)],
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- Each of transforms can be located in the any order.

## Test IKEv2.SGW.I.1.1.1.2: Sending IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH request using properly Header and Payloads format.

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: IDi Payload Format (BASIC)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (BASIC)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (BASIC)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: TSi Payload Format (BASIC)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSr Payload Format (BASIC)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 103 Header format**

- An IKE_SA Initiator’s SPI field set to same as the IKE_SA_INIT request’s IKE_SA

Initiator's SPI field value.

- An IKE_SA Responder's SPI field set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_AUTH (35).
- A Flags field set to (00010000)2 = (16)10.
- A Message ID field set to 1.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 104 Encrypted payload**

- A Next Payload field set to IDi Payload (35).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum

must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 105 ID Payload format**

- A Next Payload field set to AUTH Payload (39).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field set to ID_IPV6_ADDR (5).
- A RESERVED field set to zero.
- An Identification Data field set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 106 AUTH Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field set to Shared Key Message Integrity Code (2).
- A RESERVED field set to zero.
- An Authentication Data field set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

```
                                 1                   2                   3
             0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
            ! Next    44    !0!     0       ! Length         40             !             |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
            !       0       !       0       ! Length         36             ! |           |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
            ! Number    1   ! Prot ID   3   ! SPI Size  4   ! Trans Cnt  3  ! |           |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
            ! SPI value                                                     ! |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       3       !       0       ! Length          8             ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |SA Payload
          | ! Type  1  (EN) !       0       ! Transform ID    3      (3DES) ! | Proposal  |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       3       !       0       ! Length          8             ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | ! Type  3  (IN) !       0       ! Transform ID    2      (SHA1) ! |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | !       0       !       0       ! Length          8             ! |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |           |
          | ! Type  5  (ESN)!       0       ! Transform ID    0       (No)  ! |           |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 107 SA Payload contents**

The NUT transmits an IKE_AUTH request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 108 SA Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 109 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1 if this structure is the first proposal, otherwise set to 1 greater thatn the previous proposal.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity's SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 110 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 111 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 112 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- A Ending Address field set to greater thatn or equal to Prefix B.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 113 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 114 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix Y.
- An Ending Address field set to less than or equal to Prefix Y.

**Possible Problems:**

- IKE_AUTH request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDi,
[CERT+],
[N(INITIAL_CONTACT)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)], CERTREQ+],
[IDr],
AUTH,
[CP(CFG_REQUEST)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA,
TSi,
TSr,
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- Each of transforms can be located in the any order.

- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

## Test IKEv2.SGW.I.1.1.1.3: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |-------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<--------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |-------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                |                |                |                          SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<--------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                |                |                |                           SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |                |                |                | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT

6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TH2 can send Echo Reply to TH1 instead of sending Echo Request.

## Group 1.2. Use of Retransmission Timers

### Test IKEv2.SGW.I.1.1.2.1: Retransmissions of IKE_SA_INIT requests

**Purpose:**

To verify an IKEv2 device retransmits IKE_SA_INIT request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |                |
  |                * wait for the event of a timeout
  |                |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #2)
  |                |
  V                V
```

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 waits for the event of a timeout on NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Test IKEv2.SGW.I.1.1.2.2: Stop of retransmission of IKE_SA_INIT requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |                 |
  |                 * wait for the event of a timeout
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #2)
  |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Packet #1)
  |                 |
  |                 * wait for the event of a timeout
  |                 |
  |-------X         | never send IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #3)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 waits for the event of a timeout on NUT.
4. Observe the messages transmitted on Link A
5. TN1 responds with an IKE_SA_INIT response to the NUT.
6. TN1 waits for the event of a timeout on NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Step 7: Judgment #3**
The NUT never retransmits an IKE_SA_INIT request which has the same Message ID value as the previous IKE_SA_INIT request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

### Test IKEv2.SGW.I.1.1.2.3: Retransmissions of IKE_AUTH requests

**Purpose:**

To verify an IKEv2 device retransmits IKE_AUTH request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Packet #1)
  |                 |
  |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  |                 * wait for the event of a timeout
  |                 |
  |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Judgment #3)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 waits for the event of a timeout on NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Test IKEv2.SGW.I.1.1.2.4: Stop of retransmission of IKE_AUTH requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, set retransmission timer to 1 second.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  |                * wait for the event of a timeout
  |                |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #3)
  |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Packet #2)
  |                |
  |                * wait for the event of a timeout
  |                |
  |-------X        | never send IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #4)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 waits for the event of a timeout on NUT.

6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_AUTH response to the NUT.
8. TN1 waits for the event of a timeout on NUT.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request’s Message ID value in IKE Header.

**Step 9: Judgment #4**
The NUT never retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request’s Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different retransmission timers. If it is imposibble to configure the retransmission timer, modifying tester is required.

## Group 1.3. State Synchronization and Connection Timeouts

### Test IKEv2.SGW.I.1.1.3.1: State Synchronization with ICMP messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives ICMP messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
TH1             NUT             TR1             TN1             TH2
(Host)          (SGW)         (Router)         (SGW)           (Host)
   |               |               |               |               |
   |               |---------------+-------------->|               | IKE_SA_INIT request (HDR, SAi1,
   |               |               |               |               |                          KEi, Ni)
   |               |               |               |               | (Judgment #1)
   |               |<--------------+---------------|               | IKE_SA_INIT response (HDR, SAr1,
   |               |               |               |               |                          KEr, Nr)
   |               |               |               |               | (Packet #1)
   |               |               |               |               |
   |               |---------------+-------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH,
   |               |               |               |               |                  SAi2, TSi, TSr})
   |               |               |               |               | (Judgment #2)
   |               |<--------------+---------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH,
   |               |               |               |               |                  SAr2, TSi, TSr})
   |               |               |               |               | (Packet #2)
   |               |               |               |               |
   |<--------------+===============+===============+---------------| IPsec {Echo Request}
   |               |               |               |               | (Packet #3) (Judgment #3)
   |---------------+===============+===============+-------------->| IPsec {Echo Reply}
   |               |               |               |               | (Packet #4) (Judgment #4)
   |               |               |               |               |
   |               |<--------------|               |               | Destination Unreachable
   |               |               |               |               | (No route to destination)
   |               |               |               |               | (Packet #5)
   |               |               |               |               |
   |<--------------+===============+===============+---------------| IPsec {Echo Request}
   |               |               |               |               | (Packet #6) (Judgment #5)
   |---------------+===============+===============+-------------->| IPsec {Echo Reply}
   |               |               |               |               | (Packet #7) (Judgment #6)
   |               |               |               |               |
   V               V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #21 |
| Packet #7 | See Common Packet #25 |

Packet #5: ICMPv6 Destination Unreachable

| | | |
|---|---|---|
| IPv6 Header | Source Address | TR1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link A |
| ICMPv6 Header | Type | 1 |
| | Code | 0 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. After reception of an Echo Reply via NUT, TR1 transmits ICMP Destination Unreachable Message to the NUT and then TH2 transmits an Echo Request to the TH1.
11. Observe the messages transmitted on Link B.
12. TH1 transmits an Echo Reply to TH2.
13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT forwards an Echo Request.

**Step 13: Judgment #6**

The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.3.2: State Synchronization with IKE messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives IKE messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}
  |                |                |                | (Packet #3) (Judgment #3)
  |----------------+================+--------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |
  |                |<---------------|                | INFORMATIONAL request (HDR, N(INVALID_SPI))
  |                |                |                | (Packet #5)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}
  |                |                |                | (Packet #6) (Judgment #5)
  |----------------+================+--------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #7) (Judgment #6)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #21 |

| Packet #7 | See Common Packet #25 |
|---|---|

Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link X |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | any |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 0 |
| | Notify Message Type | 11 (INVALID_SPI) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. TN1 transmits INFORMATIONAL request with a Notify payload of type INVALID_ SPI to the NUT.
11. TH2 transmits an Echo Request to TH1.
12. Observe the messages transmitted on Link B.
13. TH1 transmits an Echo Reply to TH2.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 12: Judgment #5**
The NUT forwards an Echo Request.

**Step 14: Judgment #6**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None

## Test IKEv2.SGW.I.1.1.3.3: Close connections when repeated attempts fail

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  n each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  |                * wait for the event of a timeout
  |                |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #3)
  |                |
  |                * wait for the event of a timeout
  |                |
  |-------X        | never send IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #3)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (BASIC)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.
13. TN1 waits for the event of a timeout on the NUT.
14. Observe the messages transmitted on Link A.
15. Repeat Step 5 and Step 6 until the NUT's last restransmission comes.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Step 8: Judgment #4**
The NUT never retransmits an IKE_AUTH request which has the same Message ID value as the previous IKE_AUTH request's Message ID value in IKE Header.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.3.4: Close connections when receiving INITIAL_CONTACT

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.1.3.5: Sending Liveness check

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.1.3.6: Sending Delete Payload for IKE_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when IKE_SA is deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Packet #1)
  |                  |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2, TSi, TSr})
  |                  | (Judgment #2)
  |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2, TSi, TSr})
  |                  | (Packet #2)
  |                  |
  |                  * wait until expiring IKE_SA
  |                  |
  |--------------->| INFORMATIONAL request (HDR, SK {D})
  |                  | (Judgment #3)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 waits until expiring IKE_SA's lifetime and does not respond to an INFORMATIONAL request with an INFORMATIONAL response for liveness check.

7. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Possible Problems:**

- At Step 7, NUT can transmit INFORMATIONAL request with a Delete Payload including 2 (ESP) as Protocol ID, 4 as SPI Size and SPI value to delete CHILD_SA before transmitting an INFORMATIONAL request to delete IKE_SA.

## Test IKEv2.SGW.I.1.1.3.7: Sending Delete Payload for CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.1.3.8: Sending Liveness check with unprotected messages

This test case was deleted at revision 1.1.0.

## Group 1.4. Version Numbers and Forward Compatibility

### Test IKEv2.SGW.I.1.1.4.1: Unrecognized payload types and critical bit is not set

**Purpose:**

To verify an IKEv2 device ignores invalid payload types when the invalid type payload's critical bit is not set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
 ...              ...              ...              ...
  |                |                |                |                           ---
  |<---------------+================+----------------| IPsec {Echo Request}      | repeat Echo exchange
  |                |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
  |----------------+================+--------------->| IPsec {Echo Reply}        | is expired
  |                |                |                | (Packet #4) (Judgment #4) |
  |                |                |                |                           ---
 ...              ...              ...              ...
  |                |                |                |
  |                |--------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                |                |                | (Judgment #5)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA response (HDR, SK {P, SA, Nr, TSi, TSr})
  |                |                |                | (Packet #5)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request} (new CHILD_SA)
  |                |                |                | (Packet #6) (Judgment #6)
  |----------------+================+--------------->| IPsec {Echo Request} (new CHILD_SA)
  |                |                |                | (Packet #7) (Judgment #7)
  |                |                |                |
  V                V                V                V

N: REKEY_SA
P: Payload with an invalid payload type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #21<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 11. |
| Packet #7 | See Common Packet #25 |

Packet #5: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #16 Payload | |
| UDP Header | All fields are same as Common Packet #16 Payload | |
| IKEv2 Header | All fields are same as Common Packet #16 Payload | |
| E payload | Next Payload | *Invalid payload type value* |
| | Other fields are same as Common Packet #16 | |
| Invalid Payload | Next Payod | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 4 |

| | |
|---|---|
| SA Payload | All fields are same as Common Packet #16 Payload |
| Ni, Nr paylaod | All fields are same as Common Packet #16 Payload |
| TSi Payload | All fields are same as Common Packet #16 Payload |
| TSr Payload | All fields are same as Common Packet #16 Payload |

*Part A: Invalid payload type 1 (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 1 and the invalid payload's critical flag is not set.
13. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Response to the TH2.
16. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 (BASIC)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
22. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
23. Observe the messages transmitted on Link B.
24. TH1 transmits an Echo Reply to TH2.
25. Observe the messages transmitted on Link A.
26. Repeat Steps 22 through 25 until lifetime of SA is expired.
27. Observe the messages transmitted on Link A.
28. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 32 and the invalid payload's critical flag is not set.
29. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
30. Observe the messages transmitted on Link B.
31. TH1 transmits an Echo Response to the TH2.
32. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 (BASIC)*

33. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
34. Observe the messages transmitted on Link A.
35. TN1 responds with an IKE_SA_INIT response to the NUT.
36. Observe the messages transmitted on Link A.
37. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
38. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
39. Observe the messages transmitted on Link B.
40. TH1 transmits an Echo Reply to TH2.
41. Observe the messages transmitted on Link A.
42. Repeat Steps 38 through 41 until lifetime of SA is expired.
43. Observe the messages transmitted on Link A.
44. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 49 and the invalid payload's critical flag is not set.
45. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
46. Observe the messages transmitted on Link B.
47. TH1 transmits an Echo Response to the TH2.
48. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 (BASIC)*

49. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
50. Observe the messages transmitted on Link A.
51. TN1 responds with an IKE_SA_INIT response to the NUT.
52. Observe the messages transmitted on Link A.
53. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
54. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
55. Observe the messages transmitted on Link B.
56. TH1 transmits an Echo Reply to TH2.
57. Observe the messages transmitted on Link A.
58. Repeat Steps 54 through 57 until lifetime of SA is expired.
59. Observe the messages transmitted on Link A.
60. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 255 and the invalid payload's critical flag is not set.
61. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
62. Observe the messages transmitted on Link B.
63. TH1 transmits an Echo Response to the TH2.
64. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 14: Judgment #6**
The NUT forwards an Echo Request to the TH1.

**Step 16: Judgment #7**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part B*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 23: Judgment #3**
The NUT forwards an Echo Request.

**Step 25: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 27: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 30: Judgment #6**
The NUT forwards an Echo Request to the TH1.

**Step 32: Judgment #7**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part C*

**Step 34: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 36: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 39: Judgment #3**
The NUT forwards an Echo Request.

**Step 41: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 43: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 46: Judgment #6**
The NUT forwards an Echo Request to the TH1.

**Step 48: Judgment #7**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part D*

**Step 50: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 52: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 55: Judgment #3**
The NUT forwards an Echo Request.

**Step 57: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 59: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 62: Judgment #6**
The NUT forwards an Echo Request to the TH1.

**Step 64: Judgment #7**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.4.2: Unrecognized payload types and critical bit is set

**Purpose:**

To verify an IKEv2 device rejects the messages with invalid payload types when the invalid type payload's critical bit is set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |-------------->|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Judgment #1)
  |               |<--------------|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Packet #1)
  |               |               |               |
  |               |-------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |<--------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |               |               |
 ...             ...             ...             ...
  |               |               |               |                            ---
  |<--------------+===============+---------------| IPsec {Echo Request}       | repeat Echo exchange
  |               |               |               | (Packet #3) (Judgment #3)  | until lifetime of SA
  |---------------+===============+-------------->| IPsec {Echo Reply}         | is expired
  |               |               |               | (Packet #4) (Judgment #4)  |
  |               |               |               |                            ---
 ...             ...             ...             ...
  |               |               |               |
  |               |-------------->|               | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |               |               |               | (Judgment #5)
  |               |               |               |
  |               |<--------------|               | CREATE_CHILD_SA response (HDR, SK {P, SA, Nr, TSi, TSr})
  |               |               |               | (Packet #5)
  |               |               |               |
  |       X-------+===============+---------------| IPsec {Echo Request} (new CHILD_SA)
  |               |               |               | (Packet #6) (Judgment #6)
  |---------------+=======X       |               | IPsec {Echo Request} (new CHILD_SA)
  |               |               |               | (Packet #7) (Judgment #7)
  |               |               |               |
  V               V               V               V

N: REKEY_SA
P: Payload with an invalid payload type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #21<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 11. |
| Packet #7 | See Common Packet #25 |

Packet #5: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #16 Payload | |
| UDP Header | All fields are same as Common Packet #16 Payload | |
| IKEv2 Header | All fields are same as Common Packet #16 Payload | |
| E payload | Next Payload | *Invalid payload type value* |
| | Other fields are same as Common Packet #16 | |
| Invalid Payload | Next Payoad | 33 (SA) |
| | Critical | 1 |
| | Reserved | 0 |
| | Payload Length | 4 |
| SA Payload | All fields are same as Common Packet #16 Payload | |
| Ni, Nr payload | All fields are same as Common Packet #16 Payload | |

| | |
|---|---|
| TSi Payload | All fields are same as Common Packet #16 Payload |
| TSr Payload | All fields are same as Common Packet #16 Payload |

*Part A: Invalid payload type 1 and Critical bit is set (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload’s IKE Header Next Payload field is set to 1 and the invalid payload’s critical flag is set.
13. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Response to the TH2.
16. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 and Critical bit is set (BASIC)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
22. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
23. Observe the messages transmitted on Link B.
24. TH1 transmits an Echo Reply to TH2.
25. Observe the messages transmitted on Link A.
26. Repeat Steps 22 through 25 until lifetime of SA is expired.
27. Observe the messages transmitted on Link A.
28. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload’s IKE Header Next Payload field is set to 32 and the invalid payload’s critical flag is set.
29. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
30. Observe the messages transmitted on Link B.
31. TH1 transmits an Echo Response to the TH2.
32. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 Critical bit is set (BASIC)*

33. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
34. Observe the messages transmitted on Link A.
35. TN1 responds with an IKE_SA_INIT response to the NUT.
36. Observe the messages transmitted on Link A.
37. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
38. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
39. Observe the messages transmitted on Link B.
40. TH1 transmits an Echo Reply to TH2.
41. Observe the messages transmitted on Link A.
42. Repeat Steps 38 through 41 until lifetime of SA is expired.
43. Observe the messages transmitted on Link A.
44. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload’s IKE Header Next Payload field is set to 49 and the invalid payload’s critical flag is set.
45. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
46. Observe the messages transmitted on Link B.
47. TH1 transmits an Echo Response to the TH2.
48. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 Critical bit is set (BASIC)*

49. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
50. Observe the messages transmitted on Link A.
51. TN1 responds with an IKE_SA_INIT response to the NUT.
52. Observe the messages transmitted on Link A.
53. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
54. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
55. Observe the messages transmitted on Link B.
56. TH1 transmits an Echo Reply to TH2.
57. Observe the messages transmitted on Link A.
58. Repeat Steps 54 through 57 until lifetime of SA is expired.
59. Observe the messages transmitted on Link A.
60. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response which includes a payload with invalid payload type to the NUT. The E payload’s IKE Header Next Payload field is set to 255 and the invalid payload’s critical flag is set.
61. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
62. Observe the messages transmitted on Link B.
63. TH1 transmits an Echo Response to the TH2.
64. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 14: Judgment #6**
The NUT never forwards an Echo Request to the TH1.

**Step 16: Judgment #7**
The NUT never forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part B*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 23: Judgment #3**
The NUT forwards an Echo Request.

**Step 25: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 27: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 30: Judgment #6**
The NUT never forwards an Echo Request to the TH1.

**Step 32: Judgment #7**

The NUT never forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part C*

**Step 34: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 36: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 39: Judgment #3**
The NUT forwards an Echo Request.

**Step 41: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 43: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 46: Judgment #6**
The NUT never forwards an Echo Request to the TH1.

**Step 48: Judgment #7**
The NUT never forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

*Part D*

**Step 50: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 52: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 55: Judgment #3**
The NUT forwards an Echo Request.

**Step 57: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 59: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 62: Judgment #6**
The NUT never forwards an Echo Request to the TH1.

**Step 64: Judgment #7**
The NUT never forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

**Possible Problems:**

- None.

## Group 1.5. Cookies

### Test IKEv2.SGW.I.1.1.5.1: Retrying IKE_SA_INIT request with a Notify payload of type COOKIE

**Purpose:**

To verify an IKEv2 device retries IKE_SA_INIT request using a Notify payload of type COOKIE.

**References:**

- [RFC 4306] - Sections 2.6 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                  TN1
(SGW)                (SGW)
  |                    |
  |------------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                    | (Judgment #1)
  |<-------------------| IKE_SA_INIT response (HDR, N(COOKIE))
  |                    | (Packet #1)
  |                    |
  |------------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1, KEi, Ni)
  |                    | (Judgment #2)
  |                    |
  V                    V
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | All fields are same as Common Packet #2 |
| UDP Header | | All fields are same as Common Packet #2 |
| IKEv2 Header | IKE_SA Initiator's SPI | The same value as corresponding request's IKE_SA Initiator's SPI value |
| | IKE_SA Responder's SPI | 0 |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 34 (IKE_SA_INIT) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |

| | | |
|---|---|---|
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_SA_INIT request including a Notify payload of type COOKIE containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 115 Notify Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A SPI Size field set to zero.
- A Notify Message Type field set to COOKIE (16390).
- A Notification Data field set to the TN1 supplied cookie data.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.5.2: Interaction of COOKIE and INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles a series of the Initial Exchanges using a Notify payload of type COOKIE and type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.6, 2.7 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

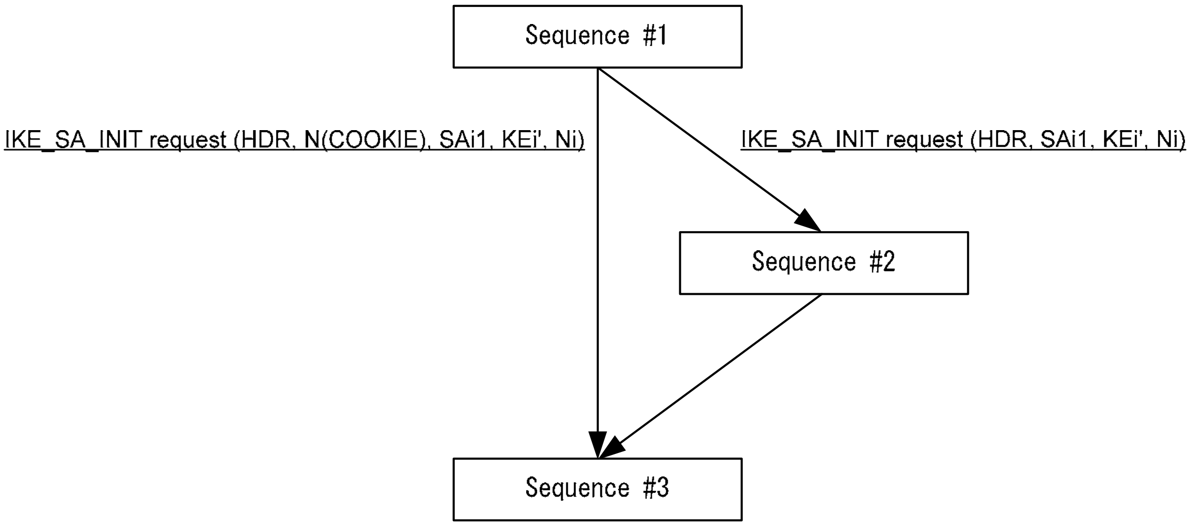
**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, configure the IKE_SA parameters as described as following. KEi payload must carry either D-H Group 14 public key value or D-H Group 24 public key value.

| | IKE_SA Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2, Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**



```
Sequence #1:
   NUT              TN1
  (SGW)            (SGW)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, N(COOKIE))
    |                | (Packet #1)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi(DH#14), Ni)
    |                | (Judgment #2)
    |<---------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
    |                | (Packet #2)
    |                |
    |------*1------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                |   or
    |------*2------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                | (Judgment #3)
    |                |
    *1) If the NUT send IKE_SA_INIT request (HDR, SAi1, KEi ' , Ni), go to Sequence #2.
    *2) If the NUT send IKE_SA_INIT request (HDR, N(COOKIE), SAi1, KEi ' , Ni), go to Sequence #3.
    Otherwise, this test is failed.

Sequence #2:
   NUT              TN1
  (SGW)            (SGW)
    |                |
    |<---------------| IKE_SA_INIT response (HDR, N(COOKIE'))
    |                | (Packet #3)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, N(COOKIE'), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
    |                | (Judgment #4)
    |                |
    Go to Sequence #3.

Sequence #3:
   NUT              TN1
  (SGW)            (SGW)
    |                |
    |<---------------| IKE_SA_INIT response (HDR, SAr1(DH#2), KEr(DH#2), Nr)
    |                | (Packet #4)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                | (Judgment #5)
    |                |
    V                V

It is possible to use DH#24 instead of DH14.
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #2 |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

Packet #2: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

Packet #3: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the common packet #1 | |
| UDP Header | Same as the common packet #1 | |
| IKEv2 Header | Other fields are same as the common packet #1 | |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Different cookie value from Packet #1's cookie value. |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD to the NUT.
6. Observe the messages transmitted on Link A.
7. If the IKE_SA_INIT request from NUT includes a Notify payload of type COOKIE, TN1 responds with an IKE_SA_INIT response. The message has a different cookie value from the cookie value at Step3.
   A) Observe the messages transmitted on Link A.
   B) TN1 responds with an IKE_SA_INIT response.
8. If the IKE_SA_INIT request from NUT does not include a Notify payload of type COOKIE, TN1 responds with an IKE_SA_INIT response.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload has D-H Group 14 public key value. Depending on configuration, it is possible to use D-H Group 24 for SA proposal and KEi payload instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request. The message has a Notify payload of type COOKIE with the cookie data supplied by the responder as the first payload. All other payloads are unchanged.

**Step 6: Judgment #3**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. The message can have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 5. All other payloads are unchanged.

**Step 7A: Judgment #4**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. The message must have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 7. All other payloads are unchanged.

**Step 9: Judgment #5**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.5.3: Interaction of COOKIE and INVALID_KE_PAYLOAD with unoptimized Responder

**Purpose:**

To verify an IKEv2 device properly handles a series of the Initial Exchanges using a Notify payload of type COOKIE and type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.6, 2.7 and 3.10.1
- [RFC 4718] - Sections 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, configure the IKE_SA parameters as described as following. KEi payload must carry either D-H Group 14 public key value or D-H Group 24 public key value.

| | IKE_SA Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2, Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
  |                  | (Judgment #1)
  |<-----------------| IKE_SA_INIT response (HDR, N(COOKIE))
  |                  | (Packet #1)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi(DH#14), Ni)
  |                  | (Judgment #2)
  |<-----------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
  |                  | (Packet #2)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
  |                  |   or
  |----------------->| IKE_SA_INIT request (HDR, N(COOKIE), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
  |                  | (Judgment #3)
  |                  |
  |<-----------------| IKE_SA_INIT response (HDR, N(COOKIE'))
  |                  | (Packet #3)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, N(COOKIE'), SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
  |                  | (Judgment #4)
  |<-----------------| IKE_SA_INIT response (HDR, SAr1(DH#2), KEr(DH#2), Nr)
  |                  | (Packet #4)
  |                  |
  |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  | (Judgment #5)
  |                  |
  V                  V

It is possible to use DH#24 instead of DH#14
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See Common Packet #2 |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as the common packet #1 |
| UDP Header | | Same as the common packet #1 |
| IKEv2 Header | | Other fields are same as the common packet #1 |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Cookie value |

Packet #2: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as the common packet #1 |
| UDP Header | | Same as the common packet #1 |
| IKEv2 Header | | Other fields are same as the common packet #1 |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |

| | | |
|---|---|---|
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

Packet #3: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as the common packet #1 |
| UDP Header | | Same as the common packet #1 |
| IKEv2 Header | | Other fields are same as the common packet #1 |
| | Next Payload | 41 (N) |
| N Payload | Next Payload | 0 (No Next Payload) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | COOKIE (16390) |
| | Notification Data | Different cookie value from Packet #1's cookie value. |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type COOKIE to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD to the NUT.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response. The message has a different cookie value from the cookie value at Step3.
8. Observe the messages transmitted on Link A.
9. TN1 responds with an IKE_SA_INIT response.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload has D-H Group 14 public key value. Depending on configuration, it is possible to use D-H Group 24 for SA proposal and KEi payload instead of D-H Group 14.

**Step 4: Judgment #2**

The NUT transmits an IKE_SA_INIT request. The message has a Notify payload of type COOKIE with the cookie data supplied by the responder as the first payload. All other payloads are unchanged.

**Step 6: Judgment #3**

The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. The message can have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 5.

**Step 8: Judgment #4**

The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. The message must have a Notify payload of type COOKIE with the cookie data supplied by the responder at Step 7. All other payloads are unchanged.

**Step 10: Judgment #5**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

# Group 1.6. Cryptographic Algorithm Negotiation

## Test IKEv2.SGW.I.1.1.6.1: Cryptographic Algorithm Negotiation for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part H, configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ***ENCR_AES_CBC*** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | DELETED | DELETED | DELETED | DELETED |
| **Part C** | ENCR_3DES | ***PRF_AES128_CBC*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_AES_XCBC_96*** | Group 2 |
| **Part E** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 14*** |
| **Part F** | ENCR_3DES | ***PRF_HMAC_SHA2_256*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part G** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_HAMC_SHA2_256_128*** | Group 2 |
| **Part H** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 24*** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

This test case is deleted at revision 1.0.4.

*Part C: Pseudo-Random Function PRF_AES128_CBC (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link B.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link B.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link B.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link B.

*Part E: D-H Group Group 14 (ADVANCED)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link B.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link B.

*Part F: PRF PRF_HMAC_SHA2_256 (ADVANCED)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link B.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link B.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link B.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link B.

*Part H: D-H Group Group 24 (ADVANCED)*

29. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
30. Observe the messages transmitted on Link B.
31. TN1 responds with an IKE_SA_INIT response to the NUT.
32. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 1.

*Part B*

This test case is deleted at revision 1.0.4.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 9.

*Part D*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_AES_XCBC_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 13.

*Part E*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as proposed algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 17.

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA2_256", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 21.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA2_256", "AUTH_HMAC_SHA2_256_128" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 25.

*Part H*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 24" as proposed algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH request which is cryptographically protected by the proposed algorithms in Step 29.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.2: Cryptographic Algorithm Negotiation for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part G, configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_AUTH exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **Extended Sequence Numbers** |
| **Part A** | ***ENCR_AES_CBC*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part B** | ***ENCR_AES_CTR*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part C** | ***ENCR_NULL*** | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part D** | ENCR_3DES | ***AUTH_AES_XCBC_96*** | No Extended Sequence Numbers |
| **Part E** | ENCR_3DES | ***NONE*** | No Extended Sequence Numbers |
| **Part F** | ENCR_3DES | AUTH_HMAC_SHA1_96 | ***Extended Sequence Numbers*** |
| **Part G** | ENCR_3DES | ***AUHT_HMAC_SHA2_256_128*** | No Extended Sequence Numbers |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
TH1           NUT           TN1           TH2
(Host)        (SGW)         (SGW)         (Host)
 |             |             |             |
 |             |------------>|             | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
 |             |             |             | (Judgment #1)
 |             |<------------|             | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
 |             |             |             | (Packet #1)
 |             |             |             |
 |             |------------>|             | IKE_AUTH request (HDR, SK {IDi, AUTH,
 |             |             |             |                          SAi2, TSi, TSr})
 |             |             |             | (Judgment #2)
 |             |<------------|             | IKE_AUTH response (HDR, SK {IDr, AUTH,
 |             |             |             |                          SAr2, TSi, TSr})
 |             |             |             | (Packet #2)
 |             |             |             |
 |<------------+=============+-------------| IPsec {Echo Request}
 |             |             |             | (Packet #3) (Judgment #3)
 |-------------+=============+------------>| IPsec {Echo Reply}
 |             |             |             | (Packet #3) (Judgment #4)
 |             |             |             |
 V             V             V             V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

| | |
|---|---|
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

10. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
11. Observe the messages transmitted on Link B.
12. TN1 responds with an IKE_SA_INIT response to the NUT.
13. Observe the messages transmitted on Link B.
14. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
15. TH2 transmits an Echo Request to TH1.
16. Observe the messages transmitted on Link A.
17. TH1 transmits an Echo Reply to TH2.
18. Observe the messages transmitted on Link B.

*Part C: Encryption Algorithm ENCR_NULL (ADVANCED)*

19. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link B.
21. TN1 responds with an IKE_SA_INIT response to the NUT.
22. Observe the messages transmitted on Link B.
23. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
24. TH2 transmits an Echo Request to TH1.
25. Observe the messages transmitted on Link A.
26. TH1 transmits an Echo Reply to TH2.
27. Observe the messages transmitted on Link B.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

28. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
29. Observe the messages transmitted on Link B.
30. TN1 responds with an IKE_SA_INIT response to the NUT.
31. Observe the messages transmitted on Link B.
32. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
33. TH2 transmits an Echo Request to TH1.
34. Observe the messages transmitted on Link A.
35. TH1 transmits an Echo Reply to TH2.
36. Observe the messages transmitted on Link B.

*Part E: Integrity Algorithm NONE (ADVANCED)*

37. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
38. Observe the messages transmitted on Link B.
39. TN1 responds with an IKE_SA_INIT response to the NUT.
40. Observe the messages transmitted on Link B.
41. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
42. TH2 transmits an Echo Request to TH1.
43. Observe the messages transmitted on Link A.
44. TH1 transmits an Echo Reply to TH2.
45. Observe the messages transmitted on Link B.

*Part F: Extended Sequence Numbers (ADVANCED)*

46. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
47. Observe the messages transmitted on Link B.
48. TN1 responds with an IKE_SA_INIT response to the NUT.
49. Observe the messages transmitted on Link B.
50. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
51. TH2 transmits an Echo Request to TH1.
52. Observe the messages transmitted on Link A.
53. TH1 transmits an Echo Reply to TH2.
54. Observe the messages transmitted on Link B.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

55. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
56. Observe the messages transmitted on Link B.
57. TN1 responds with an IKE_SA_INIT response to the NUT.
58. Observe the messages transmitted on Link B.
59. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
60. TH2 transmits an Echo Request to TH1.
61. Observe the messages transmitted on Link A.
62. TH1 transmits an Echo Reply to TH2.
63. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 11: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 13: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_AES_CTR", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 16: Judgment #3**
The NUT forwards an Echo Request.

**Step 18: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part C*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_NULL", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 25: Judgment #3**
The NUT forwards an Echo Request.

**Step 27: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part D*

**Step 29: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 31: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 34: Judgment #3**
The NUT forwards an Echo Request.

**Step 36: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part E*

**Step 38: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 40: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "NONE" and "No Extended Sequence Numbers" as proposed algorithms. However, the transform indicating "NONE" can be omitted.

**Step 43: Judgment #3**
The NUT forwards an Echo Request.

**Step 45: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part F*

**Step 47: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 49: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1" and "Extended Sequence Numbers" as proposed algorithms.

**Step 52: Judgment #3**
The NUT forwards an Echo Request.

**Step 54: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part G*

**Step 56: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 58: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA2_256_128" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 61: Judgment #3**
The NUT forwards an Echo Request.

**Step 63: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.3: Sending Multiple Transforms for IKE_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_SA_INIT request with multiple transforms for IKE_SA.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_HMAC_SHA1**<br>**PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2,**<br>**Group 14 or**<br>**Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                  TN1
(SGW)                (SGW)
  |                    |
  |------------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                    | (Judgment #1)
  V                    V
```

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link B.

*Part B: Multiple Pseudo-Random Functions (ADVANCED)*

3. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link B.

*Part C: Multiple Integrity Algorithms (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above.

6. Observe the messages transmitted on Link B.

*Part D: Multiple D-H Groups (ADVANCED)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
8. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "PRF_AES128_CBC"AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as accepted algorithms. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.4: Sending Multiple Proposals for IKE_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple proposals for CHILD_SA.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | **IKE_SA_INIT exchanges Algorithms** | | | | | |
|---|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | Proposal #1 | IKE | ENCR_ 3DES | PRF_ HMAC_SHA1 | AUTH_ HMAC_SHA1_96 | Group 2 |
| | **Proposal #2** | **IKE** | **ENCR_ AES_CBC** | **PRF_ AES128_CBC** | **AUTH_ AES_XCBC_96** | **Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |                 |
  V                 V
```

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request with 2 SA Proposals.
SA Proposal #1 (ESP) includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2".
SA Proposal #2 (ESP) includes "ENCR_AES_CBC", "PRF_AES128_CBC", "AUTH_AES_XCBC_96" and "D-H Group 14". Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.5: Sending Multiple Transforms for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple transforms for CHILD_SA.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | IKE_AUTH exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Packet #1)
  |                  |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  | (Judgment #2)
  |                  |
  V                  V
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
2. Observe the messages transmitted on Link B.
3. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.
4. Observe the messages transmitted on Link B.

*Part B: Multiple Integrity Algorithms (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
6. Observe the messages transmitted on Link B.
7. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.
8. Observe the messages transmitted on Link B.

*Part C: Extended Sequecnce Numbers (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request including a SA payload as described above to the TN1.
10. Observe the messages transmitted on Link B.
11. NUT transmits an IKE_AUTH request including a SA payload as described above to the TN1.
12. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "Extended Sequence Number" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.6: Sending Multiple Proposals for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly transmits IKE_AUTH request with multiple proposals for CHILD_SA.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration.

| | IKE_AUTH exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| | **Proposal #2** | **ESP** | **ENCR_AES_CBC** | **AUTH_AES_XCBC_96** | **ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" in SA Proposal #1 (ESP) and then "ENCR_AES_CBC", "AUTH_AES_XCBC_96" and "Extended Sequence Numbers" in SA Proposal #2 (ESP) as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.7: Receipt of INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA response with a Notify payload of type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration with enabling PFS by proposing D-H Group 2 and D-H Group 14 when rekeying. KEi payload must carry D-H Group 14 public key value in CREATE_CHILD_SA request. It is possible to use D-H Group 24 instead of D-H Group 14.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------------>|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<------------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------------>|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<------------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                                ---
  |<------------------+===================+-------------------| IPsec {Echo Request}         | repeat Echo Exchange
  |                   |                   |                   | (Packet #3) (Judgment #3)    | until lifetime of
  |-------------------+===================+------------------>| IPsec {Echo Reply}           | SA is expired
  |                   |                   |                   | (Packet #4) (Judgment #4)    |
  |                   |                   |                   |                                ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------------>|                   | CREATE_CHILD_SA request
  |                   |                   |                   |     (HDR, SK {N, SA(DH#2, DH#14),
  |                   |                   |                   |         Ni, KEi(DH#14), TSi, TSr})
  |                   |                   |                   | (Judgment #4)
  |                   |<------------------|                   | CREATE_CHILD_SA response
  |                   |                   |                   |     (HDR, SK, N(INVALID_KE_PAYLOAD(DH#2))})
  |                   |                   |                   | (Packet #5)
  |                   |                   |                   |
  |                   |------------------>|                   | CREATE_CHILD_SA request
  |                   |                   |                   |     (HDR, SK {N, SA(DH#2, DH#14),
  |                   |                   |                   |         Ni, KEi'(DH#2), TSi, TSr})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  V                   V                   V                   V

N: REKEY_SA
It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |

Packet #5: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #16 |
| UDP Header | | Same as Common Packet #16 |
| IKEv2 Header | | Same as Common Packet #16 |
| E Payload | | Same as Common Packet #16 |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT.
6. TN1 transmits an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. Repeat Steps 6 and 7 until lifetime of SA is expired.
9. Observe the messages transmitted on Link B.
10. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response with a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT.
11. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 9: Judgment #4**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers", " D-H Group 2" and " D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.
And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers", " D-H Group 2" and " D-H Group 14" as proposed algorithms and a Key Exchange payload which contains "D-H Group 2" public key value.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.6.8: Receipt of NO_PROPOSAL_CHOSEN

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.1.6.9: Response with inconsistent SA proposal for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles a response with a SA payload which is inconsistent with one of its proposals.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                 TN1
(SGW)               (SGW)
  |                   |
  |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   | (Judgment #1)
  |<------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   | (Packet #1)
  |                   |
  |-------X           | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   | (Judgment #2)
  |                   |
  V                   V
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #2 |
| UDP Header | Same as the Common Packet #2 |
| IKEv2 Header | Same as the Common Packet #2 |
| SA Payload | See below |
| KEi Payload | Same as the Common Packet #2 |
| Ni Payload | Same as the Common Packet #2 |

| | | | | |
|---|---|---|---|---|
| SA Payload | Next Payload | | | 34 (KE) |
| | Critical | | | 0 |
| | Reserved | | | 0 |
| | Payload Length | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Proposal Length | 40 |
| | | | Proposal # | 1 |
| | | | Protocol ID | 1 (IKE) |
| | | | SPI Size | 0 |
| | | | # of Transforms | 4 |

| | | | | | |
|---|---|---|---|---|---|
| | | | SA Transform | | See below |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 2 (PRF) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1) |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 4 (D-H) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (1024 MODP Group) |

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 12 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT. But the response includes a SA payload which has a different Transform ID from the proposed one.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT never transmits an IKE_AUTH request.

**Possible Problems:**

- Step 4
  The NUT may transmit or retransmit an IKE_SA_INIT request.

## Test IKEv2.SGW.I.1.1.6.10: Response with inconsistent proposal for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles a response with a SA payload which is inconsistent with one of its proposals.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |-------------->|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Judgment #1)
  |               |<--------------|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Packet #1)
  |               |               |               |
  |               |-------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |               |               |               |                          SAi2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |<--------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |               |               |               |                           SAr2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |               |               |
  |       X-------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+========X      |               | IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

Packet #2: IKE_AUTH response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #6 |
| UDP Header | Same as the Common Packet #6 |
| IKEv2 Header | Same as the Common Packet #6 |

| | |
|---|---|
| E Payload | Same as the Common Packet #6 |
| IDr Payload | Same as the Common Packet #6 |
| AUTH Payload | Same as the Common Packet #6 |
| N Payload | Same as the Common Packet #6 |
| SA Payload | See below |
| TSi Payload | Same as the Common Packet #6 |
| TSr Payload | Same as the Common Packet #6 |

| | | | | | |
|---|---|---|---|---|---|
| SA Payload | Next Payload | | | | 44 (TSi) |
| | Critical | | | | 0 |
| | Reserved | | | | 0 |
| | Payload Length | | | | 44 |
| | Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | | Reserved | | 0 |
| | | | Proposal Length | | 40 |
| | | | Proposal # | | 1 |
| | | | Protocol ID | | 3 (ESP) |
| | | | SPI Size | | 4 |
| | | | # of Transforms | | 3 |
| | | | SA Transform | | See below |
| | | | SA Transform | Next Payload | 3 (more) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 3 (INTEG) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | | SA Transform | Next Payload | 0 (last) |
| | | | | Reserved | 0 |
| | | | | Transform Length | 8 |
| | | | | Transform Type | 5 (Extended Sequence Number) |
| | | | | Reserved | 0 |
| | | | | Transform ID | 0 (No Extended Sequence Number) |

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 12 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 responds with an IKE_AUTH response to the NUT. But the response includes a SA payload which has a different Transform ID from the proposed one.
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_AES_CBC","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT never forwards an Echo Request.

**Step 9: Judgment #4**
The NUT never forwards an Echo Reply with IPsec ESP using ENCR_AES_CBC and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Step 7
  The NUT may transmit or retransmit an IKE_AUTH request. And the NUT may notify INVALID_SPI.

## Test IKEv2.SGW.I.1.1.6.11: Receipt of INVALID_KE_PAYLOAD in Initial Exchange

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT response with a Notify payload of type INVALID_KE_PAYLOAD.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. In addition, configure the IKE_SA parameters as described as following. KEi payload must carry D-H Group 14 public key value.

| | **IKE_SA Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2, Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |-------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
  |                | (Judgment #1)
  |<--------------| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
  |                | (Packet #1)
  |                |
  |-------------->| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi'(DH#2), Ni)
  |                | (Judgment #2)
  |                |
  V                V

It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #2 |
| UDP Header | | Same as Common Packet #2 |
| IKEv2 Header | | Same as Common Packet #2 |
| | IKE_SA Responder's SPI | See each Part |
| N Payload | Next Payload | 0 (No Next Payload) |

| | | |
|---|---|---|
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | INVALID_KE_PAYLOAD (17) |
| | Notification Data | The accepted D-H Group # (2) |

*Part A: IKE_SA Responder's SPI is zero (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT. The message's IKE_SA Responder's SPI is set to zero.
4. Observe the messages transmitted on Link A.

*Part B: IKE_SA Responder's SPI is not zero (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD containing 2 (1024 Bit MODP) as Notification Data to the NUT. The message's IKE_SA Responder's SPI is set to one.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. All other payloads are unchanged.

*Part B*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. KEi payload must carry "D-H Group 14" public key value. Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT request including a Key Exchange payload which contains "D-H Group 2" public key value. All other payloads are unchanged.

**Possible Problems:**

- None.

# Test IKEv2.SGW.I.1.1.6.12: Creating an IKE_SA without a CHILD_SA

**Purpose:**

To verify an IKEv2 device can handles a failure of creating a CHILD_SA during the IKE_AUTH exchange.

**References:**

- [RFC 4718] - Sections 4.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
  (SGW)            (SGW)
    |                |
    |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Judgment #1)
    |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Packet #1)
    |                |
    |--------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                | (Judgment #2)
    |<---------------| IKE_AUTH response (HDR, SK {IDr, AUTH, N(NO_PROPOSAL_CHOSEN)})
    |                | (Packet #2)
    |                |
    |<---------------| INFORMATIONAL request (HDR, SK {})
    |                | (Packet #3)
    |--------------->| INFORMATIONAL response (HDR, SK {})
    |                | (Judgment #3)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #17 |

Packet #4: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | | Same as Common Packet #6 |
| UDP Header | | Same as Common Packet #6 |
| IKEv2 Header | | Same as Common Packet #6 |
| E Payload | | Same as Common Packet #6 |
| IDr Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 24 |
| | ID Type | IPV6_ADDR |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Identification Data | TN1's Global Address on Link X |
| AUTH Payload | Next Payload | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Auth Method | 2 (SK_MIC) |
| | Reserved | 0 |
| | Authentication Data | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | NO_PROPOSAL_CHOSEN (14) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of type NO_PROPOSAL_CHOSEN to the NUT.
6. TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

# Group 1.7. Traffic Selector Negotiation

## Test IKEv2.SGW.I.1.1.7.1: Narrowing the range of members of the set of traffic selectors

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.9

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2            TH3
(Host)         (SGW)          (SGW)          (Host)         (Host)
  |              |              |              |              |
  |              |------------->|              |              | IKE_SA_INIT request (HDR, SAi1,
  |              |              |              |              |                          KEi, Ni)
  |              |              |              |              | (Judgment #1)
  |              |<-------------|              |              | IKE_SA_INIT response (HDR, SAr1,
  |              |              |              |              |                          KEr, Nr)
  |              |              |              |              | (Packet #1)
  |              |              |              |              |
  |              |------------->|              |              | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |              |              |              |              |                  SAi2, TSi, TSr})
  |              |              |              |              | (Judgment #2)
  |              |<-------------|              |              | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |              |              |              |              |                  SAr2, TSi, TSr})
  |              |              |              |              | (Packet #2)
  |              |              |              |              |
  |<-------------+==============+--------------|              | IPsec {Echo Request}
  |              |              |              |              | (Packet #3) (Judgment #3)
  |--------------+==============+------------->|              | IPsec {Echo Reply}
  |              |              |              |              | (Packet #4) (Judgment #4)
  |              |              |              |              |
  |       X------+==============+-----------------------------| IPsec {Echo Request}
  |              |              |              |              | (Packet #5) (Judgment #5)
  |---------------------------------------------------------->| IPsec {Echo Request}
  |              |              |              |              | (Packet #6) (Judgment #6)
  |              |              |              |              |
  V              V              V              V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

| | |
|---|---|
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |

Packet #5: ICMPv6 Echo Request

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #21 | |
| ESP | Same as Common Packet #21 | |
| IPv6 Header | Source Address | TH3's Global Address |
| | Other fields are same as Common Packet #21 | |
| ICMPv6 Header | Same as Common Packet #21 | |

Packet #6: ICMPv6 Echo Reply

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | TH3's Global Address |
| ICMPv6 Header | Same as Common Packet #25 | |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT.
6. TH2 transmits an Echo Request packet to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply packet to TH2.
9. Observe the messages transmitted on Link B.
10. TH3 transmits an Echo Request to TH1.
11. Observe the messages transmitted on Link A.
12. TH1 transmits an Echo Request to TH3.
13. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Request with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**

The NUT never forwards an Echo Request.

**Step 13: Judgment #6**
The NUT forwards an Echo Request without IPsec ESP.

**Possible Problems:**

- None.

Group 1.8. Error Handling

### Test IKEv2.SGW.I.1.1.8.1: INVALID_IKE_SPI

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.1.8.2: INVALID_SELECTORS

This test case was deleted at revision 1.1.0.

# Group 1.10 Authentication of the IKE_SA

## Test IKEv2.SGW.I.1.1.10.1: Sending CERT Payload

**Purpose:**

To verify an IKEv2 device handles CERTREQ payload and transmits CERT payload properly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Local | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | NUT's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | nut.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | nut@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |--------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |<---------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
  |                 | (Packet #1)
  |                 |
  |--------------->| IKE_AUTH request (HDR, SK {IDi, CERT, AUTH, SAi2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See below |

Packet #1: IKE_SA_INIT response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #2 | |
| UDP Header | Same as the Common Packet #2 | |
| IKEv2 Header | Same as the Common Packet #2 | |
| SA Payload | Same as the Common Packet #2 | |
| KE Payload | Same as the Common Packet #2 | |
| Nr Payload | Next Payload | 38 (CERTREQ) |

| | |
|---|---|
| | Other fields are same as the Common Packet #2 |
| CERTREQ Payload | See below |

| | | |
|---|---|---|
| CERTREQ Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Authority | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT request from the NUT, TN1 responds with an IKE_SA_INIT response with a CERTREQ payload to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_IPV6_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_FQDN and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request. The request includes an ID payload with ID_RFC822_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.10.2: Sending CERTREQ Payload

**Purpose:**

To verify an IKEv2 device transmits CERTREQ payload and handles CERT payload properly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Packet #1)
  |                 |
  |---------------->| IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH, SAi2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  V                 V
```

| Packet #1 | See Common Packet #2 |
|---|---|

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. TN1 responds with an IKE_SA_INIT response to the NUT.

8. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.10.3: RSA Digital Signature

**Purpose:**

To verify an IKEv2 device authenticates the corresponding node by RSA Digital Signature.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1               NUT               TN1               TH2
(Host)            (SGW)             (SGW)             (Host)
  |                 |                 |                 |
  |                 |---------------->|                 | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 |                 |                 | (Judgment #1)
  |                 |<----------------|                 | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 |                 |                 | (Packet #1)
  |                 |                 |                 |
  |                 |---------------->|                 | IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH,
  |                 |                 |                 |                            SAi2, TSi, TSr})
  |                 |                 |                 | (Judgment #2)
  |                 |<----------------|                 | IKE_AUTH response (HDR, SK {IDr, CERT, AUTH,
  |                 |                 |                 |                             SAr2, TSi, TSr})
  |                 |                 |                 | (Packet #2)
  |                 |                 |                 |
  |<----------------+=================+-----------------| IPsec {Echo Request}
  |                 |                 |                 | (Packet #3) (Judgment #3)
  |-----------------+=================+---------------->| IPsec {Echo Reply}
  |                 |                 |                 | (Packet #4) (Judgment #4)
  |                 |                 |                 |
  V                 V                 V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

Packet #2: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #6 | |
| UDP Header | Same as Common Packet #6 | |
| IKEv2 Header | Same as Common Packet #6 | |
| E Payload | Same as Common Packet #6 | |
| IDr Payload | Next Payload | 37 (CERT) |
| | Other fields are same as the Common Packet #6 | |
| CERT Payload | See below | |
| AUTH Payload | Same as Common Packet #6 | |
| SA Payload | Same as Common Packet #6 | |
| TSi Payload | Same as Common Packet #6 | |
| TSr Payload | Same as Common Packet #6 | |

| | | |
|---|---|---|
| CERT Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate - Signature) |
| | Certificate Data | TN1's X.509 Certificate |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

10. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
11. Observe the messages transmitted on Link A.
12. TN1 responds with an IKE_SA_INIT response to the NUT.
13. Observe the messages transmitted on Link A.
14. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
15. TH2 transmits an Echo Request to TH1.
16. Observe the messages transmitted on Link B.
17. TH1 transmits an Echo Reply to TH2.
18. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

19. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. TN1 responds with an IKE_SA_INIT response to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response including an IDr payload as described above and a CERT payload to the NUT
24. TH2 transmits an Echo Request to TH1.
25. Observe the messages transmitted on Link B.
26. TH1 transmits an Echo Reply to TH2.
27. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part B*

**Step 11: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 13: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 16: Judgment #3**
The NUT forwards an Echo Request.

**Step 18: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part C*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH request with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Step 25: Judgment #3**
The NUT forwards an Echo Request.

**Step 27: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.10.4: HEX string PSK

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 2.15

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | Authentication Key Value |
|---|---|
| **Remote** | 0xabadcafeabadcafeabadcafeabadcafe (128 bit binary string) |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
 (SGW)               (SGW)
   |                   |
   |------------------>| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Judgment #1)
   |<------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Packet #1)
   |                   |
   |------------------>| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                   | (Judgment #2)
   |                   |
   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

# Group 1.11 Invalid values

## Test IKEv2.SGW.I.1.1.11.1: Non zero RESERVED fields in IKE_SA_INIT response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Judgment #1)
  |<-----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Packet #1)
  |                  |
  |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  | (Judgment #2)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response whose RESERVED fields are set to one to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.11.2: Non zero RESERVED fields in IKE_AUTH response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2
(Host)         (SGW)          (SGW)          (Host)
  |              |              |              |
  |              |------------->|              | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |              |              |              | (Judgment #1)
  |              |<-------------|              | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |              |              |              | (Packet #1)
  |              |              |              |
  |              |------------->|              | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |              |              |              |                          SAi2, TSi, TSr})
  |              |              |              | (Judgment #2)
  |              |<-------------|              | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |              |              |              |                           SAr2, TSi, TSr})
  |              |              |              | (Packet #2)
  |              |              |              |
  |<-------------+==============+--------------| IPsec {Echo Request}
  |              |              |              | (Packet #3) (Judgment #3)
  |--------------+==============+------------->| IPsec {Echo Reply}
  |              |              |              | (Packet #4) (Judgment #4)
  |              |              |              |
  V              V              V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6<br>All RESERVED fields are set to one. |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH

response whose RESERVED fields are set to one to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.11.3: Version bit is set

**Purpose:**

To verify an IKEv2 device ignores the content of Version bit in IKE messages.

**References:**

- [RFC 4306] - Sections 3.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                  TN1
 (SGW)                (SGW)
   |                    |
   |------------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                    | (Judgment #1)
   |<-------------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                    | (Packet #1)
   |                    |
   |------------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                    | (Judgment #2)
   |                    |
   V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2<br>Version bit is set to one. |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response whose Version bit is set to one to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.11.4: Unrecognized Notify Message Type of Error

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type intended for reporting error.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT            TN1             TH2
(Host)          (SGW)          (SGW)           (Host)
  |               |              |               |
  |               |------------->|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |              |               | (Judgment #1)
  |               |<-------------|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |              |               | (Packet #1)
  |               |              |               |
  |               |------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |               |              |               |                            SAi2, TSi, TSr})
  |               |              |               | (Judgment #2)
  |               |<-------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |               |              |               |                            SAr2, TSi, TSr, N})
  |               |              |               | (Packet #2)
  |               |              |               |
  |      X--------+==============+---------------| IPsec {Echo Request}
  |               |              |               | (Packet #3) (Judgment #3)
  |---------------+==============+-------X       | IPsec {Echo Reply}
  |               |              |               | (Packet #4) (Judgment #4)
  |               |              |               |
  V               V              V               V

N: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #6 |
| UDP Header | All fields are same as Common Packet #6 |

| | | |
|---|---|---|
| IKEv2 Header | All fields are same as Common Packet #6 | |
| E Payload | All fields are same as Common Packet #6 | |
| IDr Payload | All fields are same as Common Packet #6 | |
| AUTH Payload | All fields are same as Common Packet #6 | |
| SA Payload | All fields are same as Common Packet #6 | |
| TSi Payload | All fields are same as Common Packet #6 | |
| TSr paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #6 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 16383 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of unrecognized Notify Message Type value.
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT never forwards an Echo Request.

**Step 9: Judgment #4**
The NUT never forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.1.11.5: Unrecognized Notify Message Type of Status

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type intended for reporting status.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |-------------->|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Judgment #1)
  |               |<--------------|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Packet #1)
  |               |               |               |
  |               |-------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |               |               |               |                           SAi2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |<--------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |               |               |               |                            SAr2, TSi, TSr, N})
  |               |               |               | (Packet #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  V               V               V               V

N: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #6 |
| UDP Header | All fields are same as Common Packet #6 |

| | | |
|---|---|---|
| IKEv2 Header | All fields are same as Common Packet #6 | |
| E Payload | All fields are same as Common Packet #6 | |
| IDr Payload | All fields are same as Common Packet #6 | |
| AUTH Payload | All fields are same as Common Packet #6 | |
| SA Payload | All fields are same as Common Packet #6 | |
| TSi Payload | All fields are same as Common Packet #6 | |
| TSr paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #6 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | 65535 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response with a Notify payload of unrecognized Notify Message Type value.
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT never forwards an Echo Request.

**Step 9: Judgment #4**
The NUT never forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

# Group 2. The CREATE_CHILD_SA Exchange

## Group 2.1. Header and Payload Formats

### Test IKEv2.SGW.I.1.2.1.1: Sending CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device transmits CREATE_CHILD_SA request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<--------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<--------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                              ---
  |<-------------+===============+--------------| IPsec {Echo Request }      | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+===============+------------->| IPsec {Echo Reply}          | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                              ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------->|                   | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  V                   V                   V                   V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link B.

*Part B: Encrypted Payload Format (BASIC)*

12. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
13. Observe the messages transmitted on Link B.
14. TN1 responds with an IKE_SA_INIT response to the NUT.
15. Observe the messages transmitted on Link B.
16. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
17. TH2 transmits an Echo Request to TH1.
18. Observe the messages transmitted on Link A.

19. TH1 transmits an Echo Reply to TH2.
20. Observe the messages transmitted on Link B.
21. Repeat Steps 6 through 9 until lifetime of SA is expired.
22. Observe the messages transmitted on Link B.

*Part C: Notify Payload (REKEY_SA) Format (BASIC)*

23. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
24. Observe the messages transmitted on Link B.
25. TN1 responds with an IKE_SA_INIT response to the NUT.
26. Observe the messages transmitted on Link B.
27. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
28. TH2 transmits an Echo Request to TH1.
29. Observe the messages transmitted on Link A.
30. TH1 transmits an Echo Reply to TH2.
31. Observe the messages transmitted on Link B.
32. Repeat Steps 6 through 9 until lifetime of SA is expired.
33. Observe the messages transmitted on Link B.

*Part D: SA Payload Format (BASIC)*

34. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
35. Observe the messages transmitted on Link B.
36. TN1 responds with an IKE_SA_INIT response to the NUT.
37. Observe the messages transmitted on Link B.
38. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
39. TH2 transmits an Echo Request to TH1.
40. Observe the messages transmitted on Link A.
41. TH1 transmits an Echo Reply to TH2.
42. Observe the messages transmitted on Link B.
43. Repeat Steps 6 through 9 until lifetime of SA is expired.
44. Observe the messages transmitted on Link B.

*Part E: Nonce Payload Format (BASIC)*

45. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
46. Observe the messages transmitted on Link B.
47. TN1 responds with an IKE_SA_INIT response to the NUT.
48. Observe the messages transmitted on Link B.
49. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
50. TH2 transmits an Echo Request to TH1.
51. Observe the messages transmitted on Link A.
52. TH1 transmits an Echo Reply to TH2.
53. Observe the messages transmitted on Link B.
54. Repeat Steps 6 through 9 until lifetime of SA is expired.
55. Observe the messages transmitted on Link B.

*Part F: TSi Payload Format (BASIC)*

56. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
57. Observe the messages transmitted on Link B.
58. TN1 responds with an IKE_SA_INIT response to the NUT.
59. Observe the messages transmitted on Link B.
60. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH

response to the NUT

61. TH2 transmits an Echo Request to TH1.
62. Observe the messages transmitted on Link A.
63. TH1 transmits an Echo Reply to TH2.
64. Observe the messages transmitted on Link B.
65. Repeat Steps 6 through 9 until lifetime of SA is expired.
66. Observe the messages transmitted on Link B.

*Part G: TSr Payload Format (BASIC)*

67. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
68. Observe the messages transmitted on Link B.
69. TN1 responds with an IKE_SA_INIT response to the NUT.
70. Observe the messages transmitted on Link B.
71. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
72. TH2 transmits an Echo Request to TH1.
73. Observe the messages transmitted on Link A.
74. TH1 transmits an Echo Reply to TH2.
75. Observe the messages transmitted on Link B.
76. Repeat Steps 6 through 9 until lifetime of SA is expired.
77. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 116 Header format**

- An IKE_SA Initiator’s SPI field set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to CREATE_CHILD_SA (36).
- A Flags field set to (00010000)2 = (16)10.
- A Message ID field set to the value incremented the previous IKE message’s Message ID by one.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 13: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 15: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 18: Judgment #3**
The NUT forwards an Echo Request.

**Step 20: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 22: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 117 Encrypted payload**

- A Next Payload field set to N Payload (41).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 24: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 26: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 29: Judgment #3**
The NUT forwards an Echo Request.

**Step 31: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 33: Judgment #5**

The NUT transmits a CREATE_CHILD_SA request including properly formatted Notify Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 118 Notify Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 12 bytes for this REKEY_SA.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to the size of CHILD_SA Inbound SPI value to be rekeyed. It is 4 bytes for ESP.
- A Notify Message Type field set to REKEY_SA (16393).
- A Security Parameter Index field set to SPI value to be rekeyed.
- A Notification Data field is empty.

*Part D*

**Step 35: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 37: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 40: Judgment #3**
The NUT forwards an Echo Request.

**Step 42: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 44: Judgment #5**

```
                            1                   2                   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
       ! Next     44    !0!       0       ! Length           40            !              |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---            |
       !       0        !         0       ! Length           36            !  |           |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       ! Number     1   ! Prot ID   3     ! SPI Size  4    ! Trans Cnt  3  !  |           |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       ! SPI value                                                         !  |           |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
     | !       3        !         0       ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
     | ! Type  1  (EN) !          0       ! Transform ID     3      (3DES) !  | Proposal |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
     | !       3        !         0       ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
     | ! Type  3  (IN) !          0       ! Transform ID     2      (SHA1) !  |           |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
     | !       0        !         0       ! Length           8             !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
     | ! Type  5  (ESN)!          0       ! Transform ID     0        (No) !  |           |
   --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 119 SA Payload contents**

The NUT transmits a CREATE_CHILD_SA request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 120 SA Payload format**

- A Next Payload field set to Ni Payload (40).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 121 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1 if this structure is the first proposal, otherwise set to 1 greater thatn the previous proposal.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity's SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 122 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.

* A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
* A Transform Type field set to INTEG (3).
* A RESERVED field set to zero.
* A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

* A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
* A RESERVED field set to zero.
* A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
* A Transform Type field set to ESN (5).
* A RESERVED field set to zero.
* A Transform ID set to No Extended Sequence Numbers (0).

*Part E*

**Step 46: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 48: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 51: Judgment #3**

The NUT forwards an Echo Request.

**Step 53: Judgment #4**

The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 55: Judgment #5**

The NUT transmits a CREATE_CHILD_SA request including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 123 Nonce Payload format**

* A Next Payload field set to TSi Payload (44).
* A Critical field set to zero.
* A RESERVED field set to zero.
* A Payload Length field set to length of the current payload.
* A Nonce Data field set to random data generated by the transmitting entity.
* The size of the Nonce must between 16 and 256 octets.

*Part F*

**Step 57: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 59: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 62: Judgment #3**

The NUT forwards an Echo Request.

**Step 64: Judgment #4**

The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 66: Judgment #5**

The NUT transmits a CREATE_CHILD_SA request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 124 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 125 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- A Ending Address field set to greater thatn or equal to Prefix B.

*Part G*

**Step 68: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 70: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 73: Judgment #3**
The NUT forwards an Echo Request.

**Step 75: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 77: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 126 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 127 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix Y.
- An Ending Address field set to less than or equal to Prefix Y.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TH2 can send Echo Reply to TH1 instead of sending Echo Request.
- The implementation may use different SA lifetimes by the implementation policy. In

that case, the tester must change the expiration time to wait CREATE_CHILD_SA request.

- CREATE_CHILD_SA request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(REKEY_SA)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, Ni, [KEi], TSi, TSr
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- Each of transforms can be located in the any order.

- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

Group 2.2. Use of Retransmission Timers

## Test IKEv2.SGW.I.1.2.2.1: Retransmissions of CREATE_CHILD_SA requests

**Purpose:**

To verify an IKEv2 device retransmits CREATE_CHILD_SA request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                    NUT                   TN1                    TH2
(Host)                 (SGW)                 (SGW)                 (Host)
  |                      |                     |                      |
  |                      |-------------->|                      | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                      |                     |                      | (Judgment #1)
  |                      |<--------------|                      | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                      |                     |                      | (Packet #1)
  |                      |                     |                      |
  |                      |-------------->|                      | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                      |                     |                      | (Judgment #2)
  |                      |<--------------|                      | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                      |                     |                      | (Packet #2)
  |                      |                     |                      |
 ...                    ...                   ...                    ...
  |                      |                     |                      |                            ---
  |<--------------+===============+--------------| IPsec {Echo Request}     | repeat Echo exchange
  |                      |                     |                      | (Packet #3) (Judgment #3) | until lifetime of SA
  |---------------+===============+------------->| IPsec {Echo Reply}       | is expired
  |                      |                     |                      | (Packet #4) (Judgment #4) |
  |                      |                     |                      |                            ---
 ...                    ...                   ...                    ...
  |                      |                     |                      |
  |                      |-------------->|                      | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                      |                     |                      | (Judgment #5)
  |                      |                     |                      |
  |                      |                     |                      * wait for the event of a timeout
  |                      |                     |                      |
  |                      |-------------->|                      | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                      |                     |                      | (Judgment #6)
  |                      |                     |                      |
  V                      V                     V                      V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH1 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TN1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link B.
12. TN1 waits for the event of a timeout on NUT.
13. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 13: Judgment #6**
The NUT retransmits a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different lifetime of SA.
- Each NUT has the different retransmission timers.

## Test IKEv2.SGW.I.1.2.2.2: Stop of retransmission of CREATE_CHILD_SA requests

**Purpose:**

To verify an IKEv2 device stops retransmission when it receives the corresponding response.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<-------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<-------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                          ---
  |<-------------+==============+-------------| IPsec {Echo Request}      | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+==============+------------>| IPsec {Echo Reply}        | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                          ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------->|                   | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  |                   |                   |                   * wait for the event of a timeout
  |                   |                   |                   |
  |                   |------------->|                   | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                   |                   | (Judgment #6)
  |                   |                   |                   |
  |                   |<-------------|                   | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                   |                   |                   | (Packet #5)
  |                   |                   |                   |
  |                   |                   |                   * wait for the event of a timeout
  |                   |                   |                   |
  |                   |-------X           |                   | never send CREATE_CHILD_SA request (HDR, SK {N, SA, Ni,
  |                   |                   |                   |                                        TSi, TSr})
  |                   |                   |                   | (Judgment #7)
  |                   |                   |                   |
  V                   V                   V                   V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #16 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Request to TH2.
9. Observe the messages transmitted on Link B.

10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link B.
12. TN1 waits for the event of a timeout on NUT.
13. Observe the messages transmitted on Link B.
14. TN1 responds with a CREATE_CHILD_SA response to the NUT.
15. TN1 waits for the event of a timeout on NUT.
16. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 13: Judgment #6**
The NUT retransmits a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Step 16: Judgment #7**
The NUT stops the retransmissions of a CREATE_CHILD_SA request which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- Each NUT has the different lifetime of SA.
- Each NUT has the different retransmission timers.

# Group 2.3. Rekeying CHILD_SA Using a CREATE_CHILD_SA exchange

## Test IKEv2.SGW.I.1.2.3.1: Close the replaced CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                TN1                TH2
(Host)              (SGW)              (SGW)              (Host)
  |                   |                  |                  |
  |                   |--------------->|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                  |                  | (Judgment #1)
  |                   |<---------------|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                  |                  | (Packet #1)
  |                   |                  |                  |
  |                   |--------------->|                  | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                  |                  | (Judgment #2)
  |                   |<---------------|                  | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                  |                  | (Packet #2)
  |                   |                  |                  |
 ...                 ...                ...                ...
  |                   |                  |                  |                             ---
  |<--------------+===============+--------------| IPsec {Echo Request}      | repeat Echo exchange
  |                   |                  |                  | (Packet #3) (Judgment #3) | until lifetime of SA
  |---------------+===============+------------->| IPsec {Echo Reply}        | is expired
  |                   |                  |                  | (Packet #4) (Judgment #4) |
  |                   |                  |                  |                             ---
 ...                 ...                ...                ...
  |                   |                  |                  |
  |                   |--------------->|                  | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                  |                  | (Judgment #5)
  |                   |                  |                  |
  |                   |<---------------|                  | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                   |                  |                  | (Packet #5)
  |                   |                  |                  |
  |                   |--------------->|                  | INFORMATIONAL request (HDR, SK {D})
  |                   |                  |                  | (Judgment #6)
  V                   V                  V                  V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #16 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.2: Use of the new CHILD_SA

**Purpose:**

To verify an IKEv2 device properly rekeys CHILD_SA

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT              TN1              TH2
(Host)             (SGW)            (SGW)            (Host)
  |                  |                |                |
  |                  |-------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                |                | (Judgment #1)
  |                  |<--------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                |                | (Packet #1)
  |                  |                |                |
  |                  |-------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                |                | (Judgment #2)
  |                  |<--------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                |                | (Packet #2)
  |                  |                |                |
 ...                ...              ...              ...
  |                  |                |                |                              ---
  |<-------------+===============+--------------| IPsec {Echo Request}        | repeat Echo exchange
  |                  |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+===============+------------->| IPsec {Echo Reply}          | is expired
  |                  |                |                | (Packet #4) (Judgment #4) |
  |                  |                |                |                              ---
 ...                ...              ...              ...
  |                  |                |                |
  |                  |-------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                  |                |                | (Judgment #5)
  |                  |                |                |
  |                  |<--------------|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                  |                |                | (Packet #5)
  |                  |                |                |
  |                  |-------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                  |                |                | (Judgment #6)
  |                  |<--------------|                | INFORMATIONAL response (HDR, SK {D})
  |                  |                |                | (Packet #6)
  |                  |                |                |
  |<-------------+===============+--------------| IPsec {Echo Request}
  |                  |                |                | (Packet #7) (Judgment #7)
  |--------------+===============+------------->| IPsec {Echo Request}
  |                  |                |                | (Packet #8) (Judgment #8)
  |                  |                |                |
  V                  V                V                V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #16 |
| Packet #6 | See below |
| Packet #7 | See Common Packet #21<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 11. |
| Packet #8 | See Common Packet #25 |

Packet #6: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |

| | | |
|---|---|---|
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value to be deleted |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response with a Delete payload to the NUT.
15. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
16. Observe the messages transmitted on Link B.
17. TH1 transmits an Echo Response to the TH2.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Step 16: Judgment #7**
The NUT forwards an Echo Request to the TH1.

**Step 18: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.3: Lifetime of CHILD_SA expires

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of CHILD_SAs.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |-------------->|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Judgment #1)
  |               |<--------------|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Packet #1)
  |               |               |               |
  |               |-------------->|               | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |<--------------|               | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  |               |               |               * wait for the event of a timeout of CHILD_SA
  |               |               |               |
  |       X-------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #5) (Judgment #5)
  |---------------+=======X       |               | IPsec {Echo Reply}
  |               |               |               | (Packet #6) (Judgment #6)
  |               |               |               |
  V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #21 |

| Packet #6 | See Common Packet #25 |
| --- | --- |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Request to TH2.
9. Observe the messages transmitted on Link B.
10. TN1 waits for the event of a timeout on the NUT.
11. After timeout of CHILD_SA on the NUT, TH2 transmits an Echo Request to the TH1.
12. Observe the messages transmitted on Link A.
13. TH1 transmits an Echo Request to TH2.
14. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 12: Judgment #5**
The NUT does not forward an Echo Request.

**Step 14: Judgment #6**
The NUT does not forward an Echo Reply with IPsec ESP using already expired CHILD_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.4: Sending Multiple Transform

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | CREATE_CHILD_SA exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1                TH2
(Host)             (SGW)              (SGW)              (Host)
  |                  |                  |                  |
  |                  |--------------->|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  |                  | (Judgment #1)
  |                  |<---------------|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                  |                  | (Packet #1)
  |                  |                  |                  |
  |                  |--------------->|                  | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                  |                  | (Judgment #2)
  |                  |<---------------|                  | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                  |                  | (Packet #2)
  |                  |                  |                  |
 ...                ...                ...                ...
  |                  |                  |                  |                              ---
  |<-------------+===============+--------------| IPsec {Echo Request}       | repeat Echo exchange
  |                  |                  |                  | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+===============+------------->| IPsec {Echo Reply}         | is expired
  |                  |                  |                  | (Packet #4) (Judgment #4) |
  |                  |                  |                  |                              ---
 ...                ...                ...                ...
  |                  |                  |                  |
  |                  |--------------->|                  | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                  |                  |                  | (Judgment #5)
  |                  |                  |                  |
  V                  V                  V                  V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link B.

*Part B: Multiple Integrity Algorithms (ADVANCED)*

12. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
13. Observe the messages transmitted on Link B.
14. TN1 responds with an IKE_SA_INIT response to the NUT.
15. Observe the messages transmitted on Link B.
16. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
17. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP

using the first negotiated algorithms to NUT.
18. Observe the messages transmitted on Link A.
19. TH1 transmits an Echo Reply to TH2.
20. Observe the messages transmitted on Link B.
21. Repeat Steps 17 through 20 until lifetime of SA is expired.
22. Observe the messages transmitted on Link B.

*Part C: Multiple Extended Sequecnce Numbers (ADVANCED)*
23. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
24. Observe the messages transmitted on Link B.
25. TN1 responds with an IKE_SA_INIT response to the NUT.
26. Observe the messages transmitted on Link B.
27. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
28. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
29. Observe the messages transmitted on Link A.
30. TH1 transmits an Echo Reply to TH2.
31. Observe the messages transmitted on Link B.
32. Repeat Steps 28 through 31 until lifetime of SA is expired.
33. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

*Part B*

**Step 13: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 15: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 18: Judgment #3**
The NUT forwards an Echo Request.

**Step 20: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 22: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

*Part C*

**Step 24: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 26: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 29: Judgment #3**
The NUT forwards an Echo Request.

**Step 31: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 33: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.5: Sending Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple proposals to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following configuration:

| | CREATE_CHILD_SA exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| | **Proposal #2** | **ESP** | **ENCR_AES_CBC** | **AUTH_AES_XCBC_96** | **ESN** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------------>|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<------------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------------>|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<------------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                          ---
  |<------------------+===================+-------------------| IPsec {Echo Request}      | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |-------------------+===================+------------------>| IPsec {Echo Reply}        | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                          ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------------>|                   | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  V                   V                   V                   V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" in SA Proposal #1 (ESP) and then "ENCR_AES_CBC", "AUTH_AES_XCBC_96" and "Extended Sequence Numbers" in SA Proposal #2 (ESP) as accepted algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.6: Rekeying Failure

**Purpose:**

To verify an IKEv2 device properly handles rekeying failure.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 30 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  TH1           NUT           TN1           TH2
 (Host)        (SGW)         (SGW)         (Host)
   |             |             |             |
   |             |------------>|             | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |             |             |             | (Judgment #1)
   |             |<------------|             | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |             |             |             | (Packet #1)
   |             |             |             |
   |             |------------>|             | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |             |             |             | (Judgment #2)
   |             |<------------|             | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |             |             |             | (Packet #2)
   |             |             |             |
  ...           ...           ...           ...
   |             |             |             |                             ---
   |<------------+=============+-------------| IPsec {Echo Request}        | repeat Echo exchange
   |             |             |             | (Packet #3) (Judgment #3)   | until lifetime of SA
   |-------------+=============+------------>| IPsec {Echo Reply}          | is expired
   |             |             |             | (Packet #4) (Judgment #4)   |
   |             |             |             |                             ---
  ...           ...           ...           ...
   |             |             |             |
   |             |------------>|             | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
   |             |             |             | (Judgment #5)
   |             |<------------|             | CREATE_CHILD_SA response
   |             |             |             |   (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
   |             |             |             | (Packet #5)
   |             |             |             |
   |             |<------------|             | INFORMATIONAL request (HDR, SK { })
   |             |             |             | (Packet #6)
   |             |-------X     |             | INFORMATIONAL response (HDR, SK { })
   |             |             |             | (Judgment #6)
   V             V             V             V
```

| Packet #1 | See Common Packet #2 |
|---|---|

| | |
|---|---|
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to the NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying IKE_SA from the NUT, TN1 rejects the NUT’s proposal. TN1 responds with a CREATE_CHILD_SA response with a Notify of type NO_PROPOSAL_CHOSEN.
13. TN1 trasnmits an INFORMATIONAL request for liveness check to the NUT.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request for rekeying IKE_SA.
The request includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 14: Judgment #6**
The NUT never responds with an INFORMATIONAL response to an INFORMATIONAL request.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.7: Perfect Forward Secrecy

**Purpose:**

To verify an IKEv2 device properly rekeys CHILD_SA when Perfect Forward Secrecy enables.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds. Enable PFS.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<--------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<--------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                                ---
  |<-------------+===============+--------------| IPsec {Echo Request}       | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+===============+------------->| IPsec {Echo Reply}         | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                                ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------->|                   | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  |                   |<--------------|                   | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                   |                   |                   | (Packet #5)
  |                   |                   |                   |
  |                   |------------->|                   | INFORMATIONAL request (HDR, SK {D})
  |                   |                   |                   | (Judgment #6)
  |                   |<--------------|                   | INFORMATIONAL response (HDR, SK {D})
  |                   |                   |                   | (Packet #6)
  |                   |                   |                   |
  |<-------------+===============+--------------| IPsec {Echo Request}
  |                   |                   |                   | (Packet #7) (Judgment #7)
  |--------------+===============+------------->| IPsec {Echo Request}
  |                   |                   |                   | (Packet #8) (Judgment #8)
  |                   |                   |                   |
  V                   V                   V                   V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See Common Packet #21<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 11. |
| Packet #8 | See Common Packet #25 |

Packet #5: CREATE_CHILD_SA response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #16 |
| UDP Header | Same as the Common Packet #16 |
| IKEv2 Header | Same as the Common Packet #16 |
| E Payload | Same as the Common Packet #16 |
| N Payload | Same as the Common Packet #16 |
| N | Same as the Common Packet #16 |

| | | |
|---|---|---|
| SA | Same as the Common Packet #16 | |
| Nr | Next Payload | 34 (KE) |
| KEr | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |
| | Key Exchange Data | any |
| TSi | Same as the Common Packet #16 | |
| TSr | Same as the Common Packet #16 | |

Packet #6: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #18 | |
| UDP Header | Same as the Common Packet #18 | |
| IKEv2 Header | Same as the Common Packet #18 | |
| E Payload | Other fields are same as the Common Packet #18 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response with a Delete payload to the NUT.
15. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the newly negotiated algorithms to NUT.
16. Observe the messages transmitted on Link B.
17. TH1 transmits an Echo Response to the TH2.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Step 16: Judgment #7**
The NUT forwards an Echo Request to the TH1.

**Step 18: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP using the second negotitated algorithms.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.3.8: Use of the old CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles new CHILD_SA and old CHILD_SA

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2
(Host)         (SGW)          (SGW)          (Host)
  |              |              |              |
  |              |------------->|              | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |              |              |              | (Judgment #1)
  |              |<-------------|              | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |              |              |              | (Packet #1)
  |              |              |              |
  |              |------------->|              | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |              |              |              | (Judgment #2)
  |              |<-------------|              | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |              |              |              | (Packet #2)
 ...            ...            ...            ...
  |              |              |              |                          ---
  |<-------------+==============+--------------| IPsec {Echo Request}      | repeat Echo exchange
  |              |              |              | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+==============+------------->| IPsec {Echo Reply}        | is expired
  |              |              |              | (Packet #4) (Judgment #4) |
  |              |              |              |                          ---
 ...            ...            ...            ...
  |              |              |              |
  |              |------------->|              | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |              |              |              | (Judgment #5)
  |              |              |              |
  |              |<-------------|              | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |              |              |              | (Packet #5)
  |              |              |              |
  |<-------------+==============+--------------| IPsec {Echo Request} (old CHILD_SA)
  |              |              |              | (Packet #6) (Judgment #6)
  |--------------+==============+------------->| IPsec {Echo Request} (old CHILD_SA or new CHILD_SA)
  |              |              |              | (Packet #7) (Judgment #7)
  V              V              V              V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #16 |
| Packet #6 | See Common Packet #21<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 5. |
| Packet #7 | See Common Packet #25 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. TH2 transmits an Echo Request to the TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms again.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Response to the TH2.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**

The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 14: Judgment #6**
The NUT forwards an Echo Request to the TH1.

**Step 16: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP. The NUT can use both the first CHILD_SA and the new CHILD_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Group 2.4. Rekeying IKE_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.SGW.I.1.2.4.1: Close the replaced IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |-------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<--------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |-------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<--------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
 ...              ...              ...              ...
  |                |                |                |                          ---
  |<--------------+===============+---------------| IPsec {Echo Request}       | repeat Echo exchange
  |                |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
  |---------------+===============+-------------->| IPsec {Echo Reply}         | is expired
  |                |                |                | (Packet #4) (Judgment #4) |
  |                |                |                |                          ---
 ...              ...              ...              ...
  |                |                |                |
  |                |-------------->|                | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                |                |                | (Judgment #5)
  |                |<--------------|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                |                |                | (Packet #5)
  |                |                |                |
  |                |-------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Judgment #6)
  |                |<--------------|                | INFROMATIONAL response (HDR, SK { })
  |                |                |                | (Packet #6)
  |                |                |                |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |                |                |                | (Packet #7) (Judgment #7)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #8) (Judgment #8)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #12 |
| Packet #6 | See Common Packet #18 |
| Packet #7 | See Common Packet #21 |
| Packet #8 | See Common Packet #25 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.

9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response to close the replaced IKE_SA.
15. TH2 transmits an Echo Request to TH1. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.
16. Observe the messages transmitted on Link A.
17. TH1 transmits an Echo Reply to TH2.
18. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 16: Judgment #7**
The NUT forwards an Echo Request.

**Step 18: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.2: Use of the new IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                  NUT                  TN1                  TH2
(Host)               (SGW)                (SGW)                (Host)
  |                    |                    |                    |
  |                    |------------------->|                    | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                    |                    |                    | (Judgment #1)
  |                    |<-------------------|                    | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                    |                    |                    | (Packet #1)
  |                    |                    |                    |
  |                    |------------------->|                    | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                    |                    |                    | (Judgment #2)
  |                    |<-------------------|                    | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                    |                    |                    | (Packet #2)
  |                    |                    |                    |
 ...                  ...                  ...                  ...
  |                    |                    |                    |                               ---
  |<-------------------+====================+--------------------| IPsec {Echo Request}         | repeat Echo exchange
  |                    |                    |                    | (Packet #3) (Judgment #3)    | until lifetime of SA
  |--------------------+====================+------------------->| IPsec {Echo Reply}           | is expired
  |                    |                    |                    | (Packet #4) (Judgment #4)    |
  |                    |                    |                    |                               ---
 ...                  ...                  ...                  ...
  |                    |                    |                    |
  |                    |------------------->|                    | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                    |                    |                    | (Judgment #5)
  |                    |<-------------------|                    | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                    |                    |                    | (Packet #5)
  |                    |                    |                    |
  |                    |------------------->|                    | INFORMATIONAL request (HDR, SK {D})
  |                    |                    |                    | (Judgment #6)
  |                    |<-------------------|                    | INFROMATIONAL response (HDR, SK { })
  |                    |                    |                    | (Packet #6)
  |                    |                    |                    |
  |                    |<-------------------|                    | INFORMATIONAL request (HDR, SK {})
  |                    |                    |                    | (Packet #7)
  |                    |------------------->|                    | INFORMATIONAL response (HDR, SK {})
  |                    |                    |                    | (Judgment #7)
  |                    |                    |                    |
  V                    V                    V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #12 |
| Packet #6 | See Common Packet #18 |
| Packet #7 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.

11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response to an INFORMATIONAL request to close the replaced IKE_SA.
15. TN1 transmits an INFORMATIONAL request with no payloads cryptographically protected by new IKE_SA.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA’s SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 16: Judgment #7**
The NUT responds with an INFORMATIONAL response with no payloads cryptographically protected by the new IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.3: Lifetime of IKE_SA expires

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |----------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Judgment #1)
  |<-----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Packet #1)
  |                  |
  |----------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  | (Judgment #2)
  |<-----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  | (Packet #2)
  |                  |
  |<-----------------| INFORMATION Request (HDR, SK {})
  |                  | (Packet #3)
  |----------------->| INFORMATIONAL response (HDR, SK {})
  |                  | (Judgment #3)
  |                  |
  |                  * wait for the event of a timeout of IKE_SA
  |                  |
  |<-----------------| INFORMATION Request (HDR, SK {})
  |                  | (Packet #4)
  |--------X         | INFORMATIONAL response (HDR, SK {})
  |                  | (Judgment #4)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #17 |
| Packet #4 | See Common Packet #17 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
7. Observe the messages transmitted on Link B.
8. TN1 waits for the event of a timeout on the NUT.
9. After timeout of CHILD_SA on the NUT, TN1 transmits an INFORMATIONAL request with no payloads using already expired IKE_SA.
10. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT responds with an INFORMATIONAL response with no payloads.

**Step 10: Judgment #4**
The NUT does not respond with an INFORMATIONAL response with no payloads using already expired IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.4: Sending Multiple Transform

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple transforms to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.

| | **CREATE_CHILD_SA exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_HMAC_SHA1**<br>**PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 2,**<br>**Group 14 or**<br>**Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |-------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<--------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |-------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<--------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                           ---
  |<--------------+===============+--------------| IPsec {Echo Request}      | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |---------------+===============+------------->| IPsec {Echo Reply}        | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                           ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |-------------->|                   | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                   |                   |                   | (Judgment #5)
  V                   V                   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (ADVANCED)*

12. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an IKE_SA_INIT response to the NUT.
15. Observe the messages transmitted on Link A.
16. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
17. TH2 transmits an Echo Request to TH1.
18. Observe the messages transmitted on Link B.
19. TH1 transmits an Echo Reply to TH2.
20. Observe the messages transmitted on Link A.
21. Repeat Steps 17 through 20 until lifetime of SA is expired.

22. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (ADVANCED)*

23. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
24. Observe the messages transmitted on Link A.
25. TN1 responds with an IKE_SA_INIT response to the NUT.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
28. TH2 transmits an Echo Request to TH1.
29. Observe the messages transmitted on Link B.
30. TH1 transmits an Echo Reply to TH2.
31. Observe the messages transmitted on Link A.
32. Repeat Steps 28 through 31 until lifetime of SA is expired.
33. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (ADVANCED)*

34. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
35. Observe the messages transmitted on Link A.
36. TN1 responds with an IKE_SA_INIT response to the NUT.
37. Observe the messages transmitted on Link A.
38. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
39. TH2 transmits an Echo Request to TH1.
40. Observe the messages transmitted on Link B.
41. TH1 transmits an Echo Reply to TH2.
42. Observe the messages transmitted on Link A.
43. Repeat Steps 39 through 42 until lifetime of SA is expired.
44. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part B*

**Step 13: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 15: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 18: Judgment #3**
The NUT forwards an Echo Request.

**Step 20: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 22: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part C*

**Step 24: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 26: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 29: Judgment #3**
The NUT forwards an Echo Request.

**Step 31: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 33: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "AUTH_AES_XCBC_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

*Part D*

**Step 35: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 37: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 40: Judgment #3**
The NUT forwards an Echo Request.

**Step 42: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 44: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2" and "D-H Group 14" as proposed algorithms. Depending on configuration, it is possible to use D-H Group 24 instead of G-H group 14.
And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.5: Sending Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly transmits CREATE_CHILD_SA request with multiple proposal to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.

| | **CREATE_CHILD_SA exchanges Algorithms** | | | | | |
|---|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | Proposal #1 | IKE | ENCR_ 3DES | PRF_ HMAC_SHA1 | AUTH_ HMAC_SHA1_96 | Group 2 |
| | **Proposal #2** | **IKE** | **ENCR_ AES_CBC** | **PRF_ AES128_CBC** | **AUTH_ AES_XCBC_96** | **Group 14 or Group 24** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<--------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<--------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                        ---
  |<-------------+==============+--------------| IPsec {Echo Request}       | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+==============+------------->| IPsec {Echo Reply}         | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                        ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |------------->|                   | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                   |                   |                   | (Judgment #5)
  V                   V                   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A: Multiple Encryption Algorithms (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request with 2 SA Proposals.
SA Proposal #1 (ESP) includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2".
SA Proposal #2 (ESP) includes "ENCR_AES_CBC", "PRF_AES128_CBC", "AUTH_AES_XCBC_96" and "D-H Group 14". Depending on configuration, it is possible to use D-H Group 24 instead of D-H Group 14.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.6: Use of the old IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles new IKE_SA and old IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2
(Host)         (SGW)          (SGW)          (Host)
  |              |              |              |
  |              |------------->|              | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |              |              |              | (Judgment #1)
  |              |<-------------|              | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |              |              |              | (Packet #1)
  |              |              |              |
  |              |------------->|              | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |              |              |              | (Judgment #2)
  |              |<-------------|              | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |              |              |              | (Packet #2)
  |              |              |              |
 ...            ...            ...            ...
  |              |              |              |                        ---
  |<-------------+==============+--------------| IPsec {Echo Request}   | repeat Echo exchange
  |              |              |              | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+==============+------------>| IPsec {Echo Reply}     | is expired
  |              |              |              | (Packet #4) (Judgment #4) |
  |              |              |              |                        ---
 ...            ...            ...            ...
  |              |              |              |
  |              |------------->|              | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |              |              |              | (Judgment #5)
  |              |              |              |
  |              |<-------------|              | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |              |              |              | (Packet #5)
  |              |              |              |
  |              |<-------------|              | INFORMATIONAL request (HDR, SK {})
  |              |              |              | (Packet #6)
  |              |------------->|              | INFORMATIONAL response (HDR, SK {})
  |              |              |              | (Judgment #6)
  V              V              V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #12 |
| Packet #6 | See Common Packet #17 (Use old IKE_SA) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request to rekey IKE_SA from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. TN1 transmits an INFORMATIONAL request with no payload to the NUT. The message is encrypted by the old IKE_SA.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 14: Judgment #6**

The NUT transmits an INFORMATIONAL response with no payload. The message is encrypted by the old IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.4.7: Changing PRFs when rekeying the IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
  Configure the devices according to the Common Configuration except for *Italic* parameters.

| | **IKE_SA Rekeying Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | ***PRF_AES128_XCBC*** | AUTH_HMAC_SHA1_96 | Group 2 |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
 ...              ...              ...              ...
  |                |                |                |                           ---
  |<---------------+================+----------------| IPsec {Echo Request}       | repeat Echo exchange
  |                |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
  |----------------+================+--------------->| IPsec {Echo Reply}         | is expired
  |                |                |                | (Packet #4) (Judgment #4) |
  |                |                |                |                           ---
 ...              ...              ...              ...
  |                |                |                |
  |                |--------------->|                | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                |                |                | (Judgment #5)
  |                |<---------------|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                |                |                | (Packet #5)
  |                |                |                |
  |                |--------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Judgment #6)
  |                |<---------------|                | INFROMATIONAL response (HDR, SK { })
  |                |                |                | (Packet #6)
  |                |                |                |
  |                |<---------------|                | INFORMATIONAL request (HDR, SK {})
  |                |                |                | (Packet #7)
  |                |--------------->|                | INFORMATIONAL response (HDR, SK {})
  |                |                |                | (Judgment #7)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #18 |
| Packet #7 | See Common Packet #17 |

Packet #5: CREATE_CHILD_SA response

Packet #5 is same as Common Packet #12 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (PRF_AES128_XCBC) |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link B.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with an INFORMATIONAL response to an INFORMATIONAL request to close the replaced IKE_SA.
15. TN1 transmits an INFORMATIONAL request with no payloads cryptographically protected by new IKE_SA.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "PRF_AES128_XCBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload to close the replaced IKE_SA.

**Step 16: Judgment #7**
The NUT responds with an INFORMATIONAL response with no payloads cryptographically protected by the new IKE_SA.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

# Group 2.5. Creating New CHILD_SAs with the CREATE_CHILD_SA Exchanges

## Test IKEv2.SGW.I.1.2.5.1: Create new CHILD_SA by sending CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to generate new CHILD_SAs.

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3
- [RFC 4718] - Sections 4.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |---------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Judgment #1)
  |<----------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Packet #1)
  |                 |
  |---------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Judgment #2)
  |<----------------| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 | (Packet #2)
  |                 |
  |---------------->| CREATE_CHILD_SA request (HDR, SK {SA, Ni, TSi, TSr})
  |                 | (Judgment #3)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See Common Packet #6 |

Packet #2: IKE_AUTH response

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #6 |
| UDP Header | Same as the Common Packet #6 |
| IKEv2 Header | Same as the Common Packet #6 |

| | | |
|---|---|---|
| E Payload | Same as the Common Packet #6 | |
| IDi Payload | Same as the Common Packet #6 | |
| AUTH Payload | Same as the Common Packet #6 | |
| N Payload | Same as the Common Packet #6 | |
| SA Payload | Same as the Common Packet #6 | |
| TSi Payload | Other fields are same as the Common Packet #6 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #6 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. NUT starts to negotiate new CHILD_SA with TN1 by sending CREATE_CHILD_SA request.
7. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.I.1.2.5.2: Receipt of cryptographically valid message on the new SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to g enerate new CHILD_SAs.

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3
- [RFC 4718] - Sections 4.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2            TH3
(Host)         (SGW)          (SGW)          (Host)         (Host)
  |              |              |              |              |
  |              |------------->|              |              | IKE_SA_INIT request (HDR, SAi1,
  |              |              |              |              |                          KEi, Ni)
  |              |              |              |              | (Judgment #1)
  |              |<-------------|              |              | IKE_SA_INIT response (HDR, SAr1,
  |              |              |              |              |                           KEr, Nr)
  |              |              |              |              | (Packet #1)
  |              |              |              |              |
  |              |------------->|              |              | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |              |              |              |              |                 SAi2, TSi, TSr})
  |              |              |              |              | (Judgment #2)
  |              |<-------------|              |              | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |              |              |              |              |                  SAr2, TSi, TSr})
  |              |              |              |              | (Packet #2)
  |              |              |              |              |
  |<-------------+==============+--------------|              | IPsec {Echo Request}
  |              |              |              |              | (Packet #3) (Judgment #3)
  |--------------+==============+------------->|              | IPsec {Echo Reply}
  |              |              |              |              | (Packet #4) (Judgment #4)
  |              |              |              |              |
  |       X------+==============+-----------------------------| IPsec {Echo Request}
  |              |              |              |              | (Packet #5) (Judgment #5)
  |--------------+=======X      |              |              | IPsec {Echo Request}
  |              |              |              |              | (Packet #6) (Judgment #6)
  |              |              |              |              |
  |              |------------->|              |              | CREATE_CHILD_SA request (HDR,
  |              |              |              |              |               SK{SA, Ni, TSi, TSr})
  |              |              |              |              | (Judgment #7)
  |              |<-------------|              |              | CREATE_CHILD_SA response (HDR,
  |              |              |              |              |               SK{SA, Nr, TSi, TSr})
  |              |              |              |              | (Packet #7)
  |              |              |              |              |
  |<-------------+==============+--------------|              | IPsec {Echo Request}
  |              |              |              |              | (Packet #8) (Judgment #8)
  |--------------+==============+------------->|              | IPsec {Echo Reply}
  |              |              |              |              | (Packet #9) (Judgment #9)
  |              |              |              |              |
  |<-------------+==============+-----------------------------| IPsec {Echo Request}
  |              |              |              |              | (Packet #10) (Judgment #10)
  |--------------+==============+---------------------------->| IPsec {Echo Reply}
  |              |              |              |              | (Packet #11) (Judgment #11)
  |              |              |              |              |
  V              V              V              V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below<br>This packet is cryptographically protected by the CHILD_SA negotiated at Step 1 to Step 5. |
| Packet #6 | See below |
| Packet #7 | See below |
| Packet #8 | See Common Packet #21 |
| Packet #9 | See Common Packet #25 |
| Packet #10 | See below<br>This packet is cryptographically protected by the |

| | |
|---|---|
| | CHILD_SA negotiated at Step 14 to Step 16. |
| Packet #11 | See below |

- Packet #2: IKE_AUTH response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #4 | |
| UDP Header | Same as the Common Packet #4 | |
| IKEv2 Header | Same as the Common Packet #4 | |
| E Payload | Same as the Common Packet #4 | |
| IDi Payload | Same as the Common Packet #4 | |
| AUTH Payload | Same as the Common Packet #4 | |
| N Payload | Same as the Common Packet #4 | |
| SA Payload | Same as the Common Packet #4 | |
| TSi Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH1's Global Address on Link B |
| | | Ending Address | TH1's Global Address on Link B |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH2's Global Address on Link Y |
| | | Ending Address | TH2's Global Address on Link Y |

- Packet #5: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #6: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Distination Address | TH3's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |

| | | |
|---|---|---|
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #7: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #4 | |
| UDP Header | Same as the Common Packet #4 | |
| IKEv2 Header | Same as the Common Packet #4 | |
| E Payload | Same as the Common Packet #4 | |
| IDi Payload | Same as the Common Packet #4 | |
| AUTH Payload | Same as the Common Packet #4 | |
| N Payload | Same as the Common Packet #4 | |
| SA Payload | Same as the Common Packet #4 | |
| TSi Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH1's Global Address on Link B |
| | | Ending Address | TH1's Global Address on Link B |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH3's Global Address on Link Y |
| | | Ending Address | TH3's Global Address on Link Y |

- Packet #10: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #11: Echo Reply

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Distination Address | TH3's Global Address |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |

| | | |
|---|---|---|
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

*Part A: (ADVANCED)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT.
6. TH2 transmits an Echo Request packet to TH1.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply packet to TH2.
9. Observe the messages transmitted on Link B.
10. TH3 transmits an Echo Request packet to TH1.
11. Observe the messages transmitted on Link A.
12. TH1 transmits an Echo Request packet to TH3.
13. Observe the messages transmitted on Link B.
14. NUT starts to negotiate new CHILD_SA with TN1 by sending CREATE_CHILD_SA request.
15. Observe the messages transmitted on Link B.
16. After a reception of CREATE_CHILD_SA request from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT with following Traffic Selector
17. TH2 transmits an Echo Request packet to TH1.
18. Observe the messages transmitted on Link A.
19. TH1 transmits an Echo Reply packet to TH2.
20. Observe the messages transmitted on Link B.
21. TH3 transmits an Echo Request packet to TH1.
22. Observe the messages transmitted on Link A.
23. TH1 transmits an Echo Reply packet to TH3.
24. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Request with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT never forwards an Echo Request.

**Step 13: Judgment #6**
The NUT never forwards an Echo Request.

**Step 15: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT forwards an Echo Request.

**Step 13: Judgment #6**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

# Group 2.6. Exchange Collisions

## Test IKEv2.SGW.I.1.2.6.1: Simultaneous CHILD_SA Close

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.2: Simultaneous IKE_SA Close

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.3: Simultaneous CHILD_SA Rekeying

**Purpose:**

To verify an IKEv2 device properly handles simultaneous CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4718] - Sections 5.11.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                |                |                |                           SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                |                |                |                            SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
 ...              ...              ...              ...
  |                |                |                |                          ---
  |<---------------+================+----------------| IPsec {Echo Request}       | repeat Echo exchange
  |                |                |                | (Packet #3) (Judgment #3)  | until lifetime of SA
  |----------------+================+--------------->| IPsec {Echo Reply}         | is expired
  |                |                |                | (Packet #4) (Judgment #4)  |
  |                |                |                |                          ---
 ...              ...              ...              ...
  |                |                |                |
  |                |--------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                |                |                | (Judgment #5)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                |                |                | (Packet #5)
  |                |--------------->|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                |                |                | (Judgment #6)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                |                |                | (Packet #6)
  |                |                |                |
  |                |--------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Judgment #7)
  |                |<---------------|                | INFORMATIONAL response (HDR, SK {D})
  |                |                |                | (Packet #7)
  |                |                |                |
  |                |--------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Judgment #8)
  |                |<---------------|                | INFORMATIONAL response (HDR, SK {D})
  |                |                |                | (Packet #8)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}  (new CHILD_SA)
  |                |                |                | (Packet #9) (Judgment #9)
  |----------------+================+--------------->| IPsec {Echo Reply}    (new CHILD_SA)
  |                |                |                | (Packet #10) (Judgment #10)
  |                |                |                |
  V                V                V                V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See Common Packet #16 |
| Packet #7 | See below |

| | |
|---|---|
| Packet #8 | See below |
| Packet #9 | See Common Packet #21 |
| Packet #10 | See Common Packet #25 |

Packet #7: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the original CHILD_SA |

Packet #8: INFORMATIONAL response

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 1 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the new CHILD_SA initiated by the NUT at Step 9 |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 and 9 until lifetime of SA expires.
11. Observe the messages transmitted on Link A.
12. TN1 transmits a CREATE_CHILD_SA request to rekey CHILD_SA to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with a CREATE_CHILD_SA response to the CRETE_CHILD_SA received at Step 9. The response message includes minimum Nonce Data.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an INFORMATIONAL response to the INFORMATIONAL request received at Step 15.
17. Observe the messages transmitted on Link A.
18. TN1 responds with an INFORMATIONAL response to the INFORMATIONAL request received at Step 17.
19. TH2 transmits an Echo Request to TH1.
20. Observe the messages transmitted on Link B.
21. TH1 transmits an Echo Reply to TH2.
22. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey a CHILD_SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 15: Judgment #7**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the original CHILD_SA.

**Step 18: Judgment #8**
The NUT transmits an INFORMATIONAL request with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the new CHILD_SA initiated by the NUT at Step 11.

**Step 20: Judgment #9**
The NUT forwards an Echo Request.

**Step 22: Judgment #10**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.6.4: Simultaneous CHILD_SA Rekeying with retransmission

**Purpose:**

To verify an IKEv2 device properly handles simultaneous CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4718] - Sections 5.11.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  TH1              NUT              TN1              TH2
 (Host)           (SGW)            (SGW)            (Host)
   |                |                |                |
   |                |-------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                |                |                | (Judgment #1)
   |                |<--------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                |                |                | (Packet #1)
   |                |                |                |
   |                |-------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH,
   |                |                |                |                            SAi2, TSi, TSr})
   |                |                |                | (Judgment #2)
   |                |<--------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH,
   |                |                |                |                             SAr2, TSi, TSr})
   |                |                |                | (Packet #2)
   |                |                |                |
  ...              ...              ...              ...
   |                |                |                |                        ---
   |<---------------+===============+----------------| IPsec {Echo Request}      | repeat Echo exchange
   |                |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
   |----------------+===============+--------------->| IPsec {Echo Reply}        | is expired
   |                |                |                | (Packet #4) (Judgment #4) |
   |                |                |                |                        ---
  ...              ...              ...              ...
   |                |                |                |
   |                |-------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
   |                |                |                | (Judgment #5)
   |                |                |                |
   |                |<--------------|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
   |                |                |                | (Packet #5)
   |                |-------------->|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
   |                |                |                | (Judgment #6)
   |                |                |                |
   |                |<--------------|                | INFORMATIONAL request (HDR, SK {D})
   |                |                |                | (Packet #6)
   |                |-------------->|                | INFORMATIONAL response (HDR, SK {D})
   |                |                |                | (Judgment #7)
   |                |                |                |
   |                |-------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
   |                |                |                | (Judgment #8)
   |                |<--------------|                | CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)}
   |                |                |                | (Packet #7)
   |                |                |                |
   |<---------------+===============+----------------| IPsec {Echo Request}  (new CHILD_SA)
   |                |                |                | (Packet #8) (Judgment #9)
   |----------------+===============+--------------->| IPsec {Echo Reply}    (new CHILD_SA)
   |                |                |                | (Packet #9) (Judgment #10)
   |                |                |                |
   V                V                V                V

 N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See below |
| Packet #7 | See below |
| Packet #8 | See Common Packet #21 |
| Packet #9 | See Common Packet #25 |

Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | 0 |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | The same value as corresponding request's Message ID |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value of the original CHILD_SA |

Packet #7: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #14 | |
| UDP Header | Same as Common Packet #14 | |
| IKEv2 Header | Same as Common Packet #14 | |
| E Payload | Same as Common Packet #14 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 10 |
| | Protocol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | NO_PROPOSAL_CHOSEN (14) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.

8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 and 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. TN1 transmits a CREATE_CHILD_SA request to rekey CHILD_SA to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 transmits an INFORMAITONAL request with a Delete Payload to close the replaced CHILD_SA.
15. Observe the messages transmitted on Link A.
16. Observe the messages transmitted on Link A.
17. TN1 responds with a CREATE_CHILD_SA response with a Notify payload of type NO_PROPOSAL_CHOSEN to the retransmitted CREATE_CHILD_SA request.
18. TH2 transmits an Echo Request to TH1.
19. Observe the messages transmitted on Link B.
20. TH1 transmits an Echo Reply to TH2.
21. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey a CHILD_SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 15: Judgment #7**
The NUT transmits an INFORMATIONAL response with a Delete Payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value of the original CHILD_SA.

**Step 16: Judgment #8**

The NUT retransmits the same CREATE_CHILD_SA request as the message at Step 11. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 19: Judgment #9**
The NUT forwards an Echo Request.

**Step 21: Judgment #10**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.6.5: Simultaneous IKE_SA Rekeying

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4718] - Sections 5.11.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |-------------->|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Judgment #1)
  |                   |<--------------|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Packet #1)
  |                   |                   |                   |
  |                   |-------------->|                   | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                   |                   |                   |                            SAi2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |<--------------|                   | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                   |                   |                   |                             SAr2, TSi, TSr})
  |                   |                   |                   | (Packet #2)
  |                   |                   |                   |
 ...                 ...                 ...                 ...
  |                   |                   |                   |                           ---
  |<--------------+===============+--------------| IPsec {Echo Request}        | repeat Echo exchange
  |                   |                   |                   | (Packet #3) (Judgment #3) | until lifetime of SA
  |--------------+===============+-------------->| IPsec {Echo Reply}          | is expired
  |                   |                   |                   | (Packet #4) (Judgment #4) |
  |                   |                   |                   |                           ---
 ...                 ...                 ...                 ...
  |                   |                   |                   |
  |                   |-------------->|                   | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                   |                   |                   | (Judgment #5)
  |                   |                   |                   |
  |                   |<--------------|                   | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                   |                   |                   | (Packet #5)
  |                   |-------------->|                   | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                   |                   |                   | (Judgment #6)
  |                   |                   |                   |
  |                   |<--------------|                   | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                   |                   |                   | (Packet #6)
  |                   |                   |                   |
  |                   |-------------->|                   | INFORMATIONAL request (HDR, SK {D})
  |                   |                   |                   | (Judgment #7)
  |                   |<--------------|                   | INFORMATIONAL response (HDR, SK {})
  |                   |                   |                   | (Packet #7)
  |                   |                   |                   |
  |                   |-------------->|                   | INFORMATIONAL request (HDR, SK {D})
  |                   |                   |                   | (Judgment #8)
  |                   |<--------------|                   | INFORMATIONAL response (HDR, SK {})
  |                   |                   |                   | (Packet #8)
  |                   |                   |                   |
  |                   |<--------------|                   | INFORMATIONAL request (HDR, SK {})  (new IKE_SA)
  |                   |                   |                   | (Packet #9)
  |                   |-------------->|                   | INFORMATIONAL response (HDR, SK {}) (new IKE_SA)
  |                   |                   |                   | (Judgment #9)
  V                   V                   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #11 |
| Packet #6 | See Common Packet #12 |
| Packet #7 | See Common Packet #18 |
| Packet #8 | See Common Packet #18 |
| Packet #8 | See Common Packet #17 |

| | |
|---|---|
| | (new IKE_SA) |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 and 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 responds with a CREATE_CHILD_SA response to the CREATE_CHILD_SA request received at Step 11. The response message includes minimum Nonce Data to make the NUT send a message to close duplicated IKE_SA.
15. Observe the messages transmitted on Link A.
16. TN1 responds with an INFORMATIONAL response with no payload.
17. Observe the messages transmitted on Link A.
18. TN1 responds with an INFORMATIONAL response with no payload.
19. TN1 transmits an INFORMATIONAL request with no payload to the NUT. The message is cryptographically protected by the new IKE_SA initiated by TN1 at Step 12.
20. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey an IKE_SA. The message includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA’s SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT responds a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the proposal in the SA payload Response has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's responder's SPI value in the SPI field.

**Step 15: Judgment #7**
The NUT transmits an INFORMATIONAL request . The message's IKE_SA Initiator's SPI value is the IKE_SA Initiator's SPI value of the original IKE_SA, and the message's IKE_SA Responder's SPI value is the IKE_SA Responder's SPI value of the original IKE_SA. The message also has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Step 17: Judgment #8**
The NUT transmits an INFORMATIONAL request . The message's IKE_SA Initiator's SPI value is the IKE_SA Initiator's SPI value of the new IKE_SA initiated by the NUT at Step 9, and the message's IKE_SA Responder's SPI value is the IKE_SA Responder's SPI value of the new IKE_SA initiated by the NUT at Step 9. The message also has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.

**Step 20: Judgment #9**
The NUT transmits an INFOMATIONAL response with no payload.

**Possible Problems:**

- Each NUT has the different lifetime of SA.
- 
- Step 15 (INFORMATIONAL request to delete the original IKE_SA) can possibly switch the place with Step 17 (INFORMATIONAL request to delte the new IKE_SA).

## Test IKEv2.SGW.I.1.2.6.6: Simultaneous IKE_SA Rekeying with retransmission

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4718] - Sections 5.11.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 60 seconds and set CHILD_SA Lifetime to 300 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1               NUT               TN1               TH2
(Host)            (SGW)             (SGW)             (Host)
  |                 |                 |                 |
  |                 |---------------->|                 | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 |                 |                 | (Judgment #1)
  |                 |<----------------|                 | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 |                 |                 | (Packet #1)
  |                 |                 |                 |
  |                 |---------------->|                 | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                 |                 |                 |                          SAi2, TSi, TSr})
  |                 |                 |                 | (Judgment #2)
  |                 |<----------------|                 | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                 |                 |                 |                           SAr2, TSi, TSr})
  |                 |                 |                 | (Packet #2)
  |                 |                 |                 |
 ...               ...               ...               ...
  |                 |                 |                 |                              ---
  |<----------------+=================+-----------------| IPsec {Echo Request}        | repeat Echo exchange
  |                 |                 |                 | (Packet #3) (Judgment #3)   | until lifetime of SA
  |-----------------+=================+---------------->| IPsec {Echo Reply}          | is expired
  |                 |                 |                 | (Packet #4) (Judgment #4)   |
  |                 |                 |                 |                              ---
 ...               ...               ...               ...
  |                 |                 |                 |
  |                 |---------------->|                 | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                 |                 |                 | (Judgment #5)
  |                 |                 |                 |
  |                 |<----------------|                 | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                 |                 |                 | (Packet #5)
  |                 |---------------->|                 | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                 |                 |                 | (Judgment #6)
  |                 |                 |                 |
  |                 |<----------------|                 | INFORMATIONAL request (HDR, SK {D})
  |                 |                 |                 | (Packet #6)
  |                 |---------------->|                 | INFORMATIONAL response (HDR, SK {})
  |                 |                 |                 | (Judgment #7)
  |                 |                 |                 |
  |                 |-------X         |                 | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                 |                 |                 | (Judgment #8)
  V                 V                 V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #11 |
| Packet #6 | See below |

Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |

| | | |
|---|---|---|
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index | none |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 and 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA to the NUT.
13. Observe the messages transmitted on Link A.
14. TN1 transmits an INFORMATONAL request to close the original IKE_SA. The message has a Delete Payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.
15. Observe the messages transmitted on Link A.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey an IKE_SA. The message includes "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the CREATE_CHILD_SA request has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT responds a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the proposal in the SA payload Response has a SA payload including 1 (IKE) in the Protocol ID field, 8 in the SPI size field and new IKE_SA's responder's SPI value in the SPI field.

**Step 15: Judgment #7**
The NUT responds with an INFOMATIONAL response to the INFORMATIONAL request to close the original IKE_SA.

**Step 16: Judgment #8**
The NUT never retransmits a CREATE_CHILD_SA request transmitted at Step 11.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

## Test IKEv2.SGW.I.1.2.6.7: Rekeying a CHILD_SA while Closing a CHILD_SA

This test case was deleted at revision 1.1.0.

### Test IKEv2.SGW.I.1.2.6.8: Closing a New CHILD_SA

This test case was deleted at revision 1.1.0.

### Test IKEv2.SGW.I.1.2.6.9: Rekeying a New CHILD_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.10: Rekeying an IKE_SA with half-open CHILD_SAs

This test case was deleted at revision 1.1.0.

### Test IKEv2.SGW.I.1.2.6.11: Rekeying a CHILD_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.12: Rekeying an IKE_SA with half-closed CHILD_SAs

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.13: Closing a CHILD_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.14: Closing an IKE_SA while rekeying an IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.2.6.15: Rekeying an IKE _SA while Closing an IKE_SA

This test case was deleted at revision 1.1.0.

# Group 2.7. Non zero RESERVED fields

## Test IKEv2.SGW.I.1.2.7.1: Non zero RESERVED fields in CREATE_CHILD_SA response

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |--------------->|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Judgment #1)
  |                |<---------------|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Packet #1)
  |                |                |                |
  |                |--------------->|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |<---------------|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |                |                |
 ...              ...              ...              ...
  |                |                |                |                            ---
  |<---------------+================+----------------| IPsec {Echo Request}       | repeat Echo exchange
  |                |                |                | (Packet #3) (Judgment #3) | until lifetime of SA
  |----------------+================+--------------->| IPsec {Echo Reply}         | is expired
  |                |                |                | (Packet #4) (Judgment #4) |
  |                |                |                |                            ---
 ...              ...              ...              ...
  |                |                |                |
  |                |--------------->|                | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                |                |                | (Judgment #5)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                |                |                | (Packet #5)
  |                |                |                |
  |                |--------------->|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Judgment #6)
  V                V                V                V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #16<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP using the first negotiated algorithms to NUT.
7. Observe the messages transmitted on Link B.
8. TH1 transmits an Echo Reply to TH2.
9. Observe the messages transmitted on Link A.
10. Repeat Steps 6 through 9 until lifetime of SA is expired.
11. Observe the messages transmitted on Link A.
12. After reception of CREATE_CHILD_SA request for rekeying from the NUT, TN1 responds with a CREATE_CHILD_SA response to the NUT. All RESERVED fields in the message are set to one.

13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotitated algorithms.

**Step 11: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 13: Judgment #6**
The NUT transmits an INFORMATIONAL request with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the inblund SPI value to be deleted as SPI.

**Possible Problems:**

- Each NUT has the different lifetime of SA.

Group 3. The INFORMATIONAL Exchange

## Group 3.1. Header and Payload Formats

### Test IKEv2.SGW.I.1.3.1.1: Sending INFORMATIONAL Exchange

This test case was deleted at revision 1.1.0.

## Group 3.2. Use of Retransmission Timers

### Test IKEv2.SGW.I.1.3.2.1: Retransmission of INFORMATIONAL request

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.I.1.3.2.2: Stop of retransmission of INFORMATIONAL request

This test case was deleted at revision 1.1.0.

## Group 3.3. Non zero RESERVED fields

### Test IKEv2.SGW.I.1.3.3.1: Non zero RESERVED fields in INFORMATIONAL response

This test case was deleted at revision 1.1.0.

## Group 3.4. Error Handling

### Test IKEv2.SGW.I.1.3.4.1: INVALID_SPI

This test case was deleted at revision 1.1.0.

# Section 2.1.2. Endpoint to Security Gateway Tunnel

# Group 1. The Initial Exchanges

## Group 1.1. Header and Payload Formats

### Test IKEv2.SGW.I.2.1.1.1: Sending IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)         (End-Node)
  |                |
  |-------------->| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Judgment #1)
  |<--------------| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Packet #1)
  |                |
  |-------------->| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |

*Part A: IKE Header Format (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.

*Part B: Encrypted Payload Format (BASIC)*

5. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link B.
7. TN1 responds with an IKE_SA_INIT response to the NUT.

8. Observe the messages transmitted on Link B.

*Part C: IDi Payload Format (BASIC)*

9. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link B.
11. TN1 responds with an IKE_SA_INIT response to the NUT.
12. Observe the messages transmitted on Link B.

*Part D: AUTH Payload Format (BASIC)*

13. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link B.
15. TN1 responds with an IKE_SA_INIT response to the NUT.
16. Observe the messages transmitted on Link B.

*Part E: SA Payload Format (BASIC)*

17. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link B.
19. TN1 responds with an IKE_SA_INIT response to the NUT.
20. Observe the messages transmitted on Link B.

*Part F: TSi Payload Format (BASIC)*

21. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link B.
23. TN1 responds with an IKE_SA_INIT response to the NUT.
24. Observe the messages transmitted on Link B.

*Part G: TSr Payload Format (BASIC)*

25. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link B.
27. TN1 responds with an IKE_SA_INIT response to the NUT.
28. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 128 Header format**

- An IKE_SA Initiator's SPI field set to same as the IKE_SA_INIT request's IKE_SA Initiator's SPI field value.
- An IKE_SA Responder's SPI field set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_AUTH (35).
- A Flags field set to (00010000)2 = (1610).
- A Message ID field set to 1.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH request including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 129 Encrypted payload**

- A Next Payload field set to IDi Payload (35).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 130 ID Payload format**

- A Next Payload field set to AUTH Payload (39).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field set to ID_IPV6_ADDR (5).
- A RESERVED field set to zero.
- An Identification Data field set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 131 AUTH Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field set to Shared Key Message Integrity Code (2).
- A RESERVED field set to zero.
- An Authentication Data field set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

```
                             1                   2                   3
         0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
        ! Next     44    !0!      0      ! Length           40           !              |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---           |
        !       0        !        0      ! Length           36           !  |           |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        ! Number     1   ! Prot ID    3  ! SPI Size   4   ! Trans Cnt  3 !  |           |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
        ! SPI value                                                      !  |           |
    --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
      | !       3        !        0      ! Length            8           !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
      | ! Type   1  (EN) !        0      ! Transform ID      3     (3DES) !  | Proposal  |
    --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
      | !       3        !        0      ! Length            8           !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
      | ! Type   3  (IN) !        0      ! Transform ID      2     (SHA1) !  |           |
    --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
      | !       0        !        0      ! Length            8           !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
      | ! Type   5  (ESN)!        0      ! Transform ID      0       (No) !  |           |
    --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 132 SA Payload contents**

The NUT transmits an IKE_AUTH request including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 133 SA Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

The following proposal must be included in Proposals field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 134 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero if this structure is the last proposal, otherwise set to 2.
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1 if this structure is the first proposal, otherwise set to 1 greater thatn the previous proposal.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity's SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 135 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.

- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 136 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 137 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- A Ending Address field set to greater thatn or equal to Prefix B.

*Part G*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH request including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 138 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

The following traffic selector must be included in Traffic Selectors field.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 139 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to TN1 address.
- An Ending Address field set to less than or equal to TN1 address.

**Possible Problems:**

- IKE_AUTH request has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDi,
[CERT+],
[N(INITIAL_CONTACT)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)], CERTREQ+],
[IDr],
AUTH,
[CP(CFG_REQUEST)],
[N(IPCOMP_SUPPORTED)+],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA,
TSi,
TSr,
[V+]
```

- The implementation may not set single proposal by the implementation policy. In this case, Security Association Payload contains multiple proposals.

- The implementation may not set single traffic selector by the implementation policy. In this case, Traffic Selector Payload contains multiple proposals.

- Each of transforms can be located in the any order.

## Test IKEv2.SGW.I.2.1.1.2: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                  TN1
(Host)              (SGW)              (End-Node)
  |                   |                    |
  |                   |-------------->|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                    |  (Judgment #1)
  |                   |<--------------|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                    |  (Packet #1)
  |                   |                    |
  |                   |-------------->|  IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   |                    |  (Judgment #2)
  |                   |<--------------|  IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                   |                    |  (Packet #2)
  |                   |                    |
  |<--------------+===============|  IPsec {Echo Request}
  |                   |                    |  (Judgment #3)
  |---------------+==============>|  IPsec {Echo Reply}
  |                   |                    |  (Judgment #4)
  |                   |                    |
  V                   V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |

*Part A (BASIC)*

1. NUT starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. TN1 responds with an IKE_SA_INIT response to the NUT.
4. Observe the messages transmitted on Link B.
5. After reception of IKE_AUTH request from the NUT, TN1 responds with an IKE_AUTH response to the NUT
6. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to NUT.
7. Observe the messages transmitted on Link A.
8. TH1 transmits an Echo Reply to TN1.
9. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT forwards an Echo Request.

**Step 9: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TN1 can send Echo Reply to TH1 instead of sending Echo Request.

**Section 2.2. Responder**
**Section 2.2.1. Security Gateway to Security Gateway Tunnel**
**Group 1. The Initial Exchanges**

# Group 1.1. Header and Payload Formats

## Test IKEv2.SGW.R.1.1.1.1: Sending IKE_SA_INIT response

**Purpose:**

To verify an IKEv2 device transmits IKE_SA_INIT response using properly Header and Payloads format

**References:**

- [RFC4306] - Section 1.2, 2.10, 3.1, 3.2, 3.3, 3.4 and 3.9
- [RFC 4718] - Sections 7.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Judgment #1)
   V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B: SA Payload Format (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C: KE Payload Format (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

*Part D: Nonce Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 140 Header format**

- An IKE_SA Initiator's SPI field set to IKE_SA Initiator's SPI field value supplied in the first IKE_SA_INIT request message.
- An IKE_SA Responder's SPI field set to a 64-bits value chosen by the NUT. It MUST not be zero.
- A Next Payload field set to SA Payload (33).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_SA_INIT (34).
- A Flags field set to (00000100)2 = (4)10.
- A Message ID field set to zero.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 4: Judgment #1**

```
                                 1                   2                   3
             0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
            ! Next    34    !0!     0       ! Length          44            !            |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---        |
            !       0       !       0       ! Length          40            ! |          |
            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
            ! Number    1   ! Prot ID   1   ! SPI Size  0   ! Trans Cnt  4  ! |          |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | !       3       !       0       ! Length           8            ! |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | ! Type  1  (EN) !       0       ! Transform ID     3     (3DES) ! |          |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | !       3       !       0       ! Length           8            ! |          |SA Payload
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |Proposal  |
          | ! Type  2  (PR) !       0       ! Transform ID     2     (SHA1) ! |          |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | !       3       !       0       ! Length           8            ! |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | ! Type  3  (IN) !       0       ! Transform ID     2     (SHA1) ! |          |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | !       0       !       0       ! Length           8            ! |          |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |          |
          | ! Type  4  (DH) !       0       ! Transform ID     2     (1024) ! |          |
        --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 141 SA Payload contents**

The NUT transmits an IKE_SA_INIT response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 142 SA Payload format**

- A Next Payload field set to KE Payload (34).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

A Proposals field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 143 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero (last).
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 40 bytes for this proposal according to Common Configuration.
- A Proposal # field set to 1.
- A Protocol ID field set to IKE (1).
- A SPI Size field set to zero.
- A # of Transforms field set to 4.

A Transform field set to following (There are 4 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 144 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including

Header and Attribute. It is 8 bytes for PRF_HMAC_SHA1.

- A Transform Type field set to PRF (2).
- A RESERVED field set to zero.
- A Transform ID set to PRF_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.
- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #4

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for 1024 MODP Group.
- A Transform Type field set to D-H (4).
- A RESERVED field set to zero.
- A Transform ID set to Group2 (2).

*Part C*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including properly formatted KE Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!          DH Group #           !           RESERVED            !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Key Exchange Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 145 KE Payload format**

- A Next Payload field set to Nonce Payload (40).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 136 bytes for Group 2.
- A DH Group field set to Group2 (2).
- A RESERVED field set to zero.
- A Key Exchange Data field set to Diffie-Hellman public value. The length of the Key Exchange Data field must be equal to 1024bit.

*Part D*

**Step 8: Judgment #4**

The NUT transmits an IKE_SA_INIT response including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 146 Nonce Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Nonce Data field set to random data generated by the transmitting entity. The size of the Nonce must between 16 and 256 octets.

**Possible Problems:**

- IKE_SA_INIT response has following packet format. It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
SA, KE, Nr,
[N(NAT_DETECTION_SOURCE_IP),
 N(NAT_DETECTION_DESTINATION_IP)],
[[N(HTTP_CERT_LOOKUP_SUPPORTED)], CERTREQ+],
[V+]
```

- Each of transforms can be located in the any order.

## Test IKEv2.SGW.R.1.1.1.2: Sending IKE_AUTH response

**Purpose:**

To verify an IKEv2 device transmits IKE_AUHT response using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT             TN1
 (SGW)           (SGW)
   |               |
   |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |               | (Packet #1)
   |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |               | (Judgment #1)
   |               |
   |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |               | (Packet #2)
   |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |               | (Judgment #2)
   V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: IDr Payload Format (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (BASIC)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: TSi Payload Format (BASIC)*

21. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSr Payload Format (BASIC)*

25. TN1starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
28. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 147 Header format**

- An IKE_SA Initiator’s SPI field set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_AUTH (35).
- A Flags field set to (00000100)2 = (4)10.
- A Message ID field set to 1.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 148 Encrypted payload**

- A Next Payload field set to IDr Payload (36).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 149 ID Payload format**

- A Next Payload field set to AUTH Payload (39).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field set to ID_IPV6_ADDR (5).
- A RESERVED field set to zero.
- An Identification Data field set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 150 AUTH Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field set to Shared Key Message Integrity Code (2).
- A RESERVED field set to zero.
- An Authentication Data field set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 20: Judgment #2**

```
                            1                   2                   3
          0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
         ! Next    44    !0!      0      ! Length          40            !             |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
         !       0       !        0      ! Length          36            !  |          |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
         ! Number     1  ! Prot ID    3  ! SPI Size  4   ! Trans Cnt  3  !  |          |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
         ! SPI value                                                     !  |          |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        |!       3       !        0      ! Length           8            !  |          |
Transform|+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |SA Payload
        |! Type  1  (EN) !        0      ! Transform ID     3      (3DES) !  | Proposal |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        |!       3       !        0      ! Length           8            !  |          |
Transform|+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        |! Type  3  (IN) !        0      ! Transform ID     2      (SHA1) !  |          |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        |!       0       !        0      ! Length           8            !  |          |
Transform|+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |          |
        |! Type  5  (ESN)!        0      ! Transform ID     0       (No)  !  |          |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ -------------
```

**Figure 151 SA Payload contents**

The NUT transmits an IKE_AUTH response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 152 SA Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

A Proposals field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 153 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero (last).
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity's SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 154 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including

Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.

- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 24: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 155 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Starting Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Ending Address*                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 156 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix Y.
- A Ending Address field set to greater thatn or equal to Prefix Y.

*Part G*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 157 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Starting Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Ending Address*                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 158 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- An Ending Address field set to less than or equal to Prefix B.

**Possible Problems:**

- IKE_AUTH response has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDr, [CERT+],
AUTH,
[CP(CFG_REPLY)],
[N(IPCOMP_SUPPORTED)],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, TSi, TSr,
[N(ADDITIONAL_TS_POSSIBLE)],
[V+]
```

- Each of transforms can be located in the any order.

## Test IKEv2.SGW.R.1.1.1.3: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key.

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1            NUT            TN1            TH2
(Host)         (SGW)          (SGW)          (Host)
  |              |              |              |
  |              |<-------------|              | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |              |              |              | (Packet #1)
  |              |------------->|              | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |              |              |              | (Judgment #1)
  |              |              |              |
  |              |<-------------|              | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |              |              |              |                          SAi2, TSi, TSr})
  |              |              |              | (Packet #2)
  |              |------------->|              | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |              |              |              |                           SAr2, TSi, TSr})
  |              |              |              | (Judgment #2)
  |              |              |              |
  |<-------------+==============+--------------| IPsec {Echo Request}
  |              |              |              | (Packet#3) (Judgment #3)
  |--------------+==============+------------->| IPsec {Echo Reply}
  |              |              |              | (Packet #4) (Judgment #4)
  |              |              |              |
  V              V              V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

*Part A (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.

6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TH2 can send Echo Reply to TH1 instead of sending Echo Request.

## Group 1.2. Use of Retransmission Timers

### Test IKEv2.SGW.R.1.1.2.1: Receipt of retransmitted IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device transmits IKE_SA_INIT response, if a retransmission of the response is triggered.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4
- [RFC 4718] - Sections 2.2 and 2.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #1)
  |               |
  |               * wait until retrans timer expires
  |-------X       | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #3)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #2)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #3)
  |               |
  V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #1<br>(The Message ID is the same as Packet #1) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with TN1 by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. Observe the messages transmitted on Link A.
4. TN1 retransmits the same IKE_SA_INIT request as the message transmitted in Step 1 to the

NUT.

5. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 3: Judgment #2**

The NUT never retransmits the same IKE_SA_INIT response as the response transmitted at Step 2.

**Step 5: Judgment #3**

The NUT transmits the same IKE_SA_INIT response as the response transmitted at Step 2.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.2.2: Receipt of retransmitted IKE_AUTH request

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH response, if a retransmission of the response is triggered.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
    NUT              TN1
(End-Node)       (End-Node)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |                * wait until retrans timer expires
    |-------X        | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                | (Judgment #3)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                | (Packet #3)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                | (Judgment #4)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #5<br>(The Message ID is the same as Packet #2) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_AUTH request to the NUT.

4. Observe the messages transmitted on Link A.
5. Observe the messages transmitted on Link A.
6. TN1 retransmits the same IKE_AUTH request as the request transmitted in Step 3 to the NUT.
7. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES","PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 5: Judgment #3**
The NUT never retransmits the same IKE_AUTH response as the response transmitted at Step 4.

**Step 7: Judgment #4**
The NUT transmits the same IKE_AUTH response as the response transmitted at Step 4.

**Possible Problems:**

- None.

# Group 1.3. State Synchronization and Connection Timeouts

## Test IKEv2.SGW.R.1.1.3.1: State Synchronization with ICMP messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives ICMP messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TR1             TN1             TH2
(Host)          (SGW)          (Router)         (SGW)           (Host)
  |               |               |               |               |
  |               |<--------------+---------------|               | IKE_SA_INIT request
  |               |               |               |               |   (HDR, SAi1, KEi, Ni)
  |               |               |               |               | (Packet #1)
  |               |---------------+-------------->|               | IKE_SA_INIT response
  |               |               |               |               |   (HDR, SAr1, KEr, Nr)
  |               |               |               |               | (Judgment #1)
  |               |               |               |               |
  |               |<--------------+---------------|               | IKE_AUTH request
  |               |               |               |               |  (HDR, SK {IDi, AUTH,SAi2, TSi, TSr})
  |               |               |               |               | (Packet #2)
  |               |---------------+-------------->|               | IKE_AUTH response
  |               |               |               |               |  (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               |               | (Judgment #2)
  |               |               |               |               |
  |<--------------+===============+===============+---------------| IPsec {Echo Request}
  |               |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+===============+-------------->| IPsec {Echo Reply}
  |               |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |               |
  |               |<--------------|               |               | Destination Unreachable
  |               |               |               |               |  (No route to destination)
  |               |               |               |               | (Packet #5)
  |               |               |               |               |
  |<--------------+===============+===============+---------------| IPsec {Echo Request}
  |               |               |               |               | (Packet #6) (Judgment #5)
  |---------------+===============+===============+-------------->| IPsec {Echo Reply}
  |               |               |               |               | (Packet #7) (Judgment #6)
  |               |               |               |               |
  V               V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See Common Packet #21 |
| Packet #7 | See Common Packet #25 |

- Packet #5: ICMPv6 Destination Unreachable

| | | | | |
|---|---|---|---|---|
| IPv6 Header | Source Address | | | TR1's Global Address on Link A |
| | Destination Address | | | NUT's Global Address on Link A |
| ICMPv6 | Type | | | 1 |
| | Code | | | 0 |
| | Data | IP Header | Source Address | NUT's Global Address on Link A |
| | | | Destination Address | TN1's Global Address on Link X |
| | | | Next Header | 50 (ESP) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1 and TN1 forwards the Echo Request with IPsec ESP using corresponding algorithms to the NUT.
6. Observe the messages transmitted on Link A.
7. After reception of an Echo Request from the NUT, TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TR1 transmit an ICMP Destination Unreachable Message to the NUT.
10. TH2 transmits an Echo Request to TH1 and TN1 forwards the Echo Request with IPsec ESP using corresponding algorithms to the NUT.
11. Observe the messages transmitted on Link A.
12. After reception of an Echo Request from the NUT, TH1 transmits an Echo Reply to TH2.
13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT forwards an Echo Request.

**Step 13: Judgment #6**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.3.2: State Synchronization with IKE messages

**Purpose:**

To verify an IKEv2 device synchronizes its state when it receives IKE messages.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TR1             TN1             TH2
(Host)          (SGW)          (Router)         (SGW)           (Host)
  |               |               |               |               |
  |               |<--------------+---------------|               | IKE_SA_INIT request
  |               |               |               |               |  (HDR, SAi1, KEi, Ni)
  |               |               |               |               | (Packet #1)
  |               |---------------+-------------->|               | IKE_SA_INIT response
  |               |               |               |               |  (HDR, SAr1, KEr, Nr)
  |               |               |               |               | (Judgment #1)
  |               |               |               |               |
  |               |<--------------+---------------|               | IKE_AUTH request
  |               |               |               |               |  (HDR, SK {IDi, AUTH,SAi2, TSi, TSr})
  |               |               |               |               | (Packet #2)
  |               |---------------+-------------->|               | IKE_AUTH response
  |               |               |               |               |  (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               |               | (Judgment #2)
  |               |               |               |               |
  |<--------------+===============+===============+---------------| IPsec {Echo Request}
  |               |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+===============+-------------->| IPsec {Echo Reply}
  |               |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |               |
  |               |<--------------+---------------|               | IKE Message
  |               |               |               |               | (Packet #5)
  |               |               |               |               |
  |<--------------+===============+===============+---------------| IPsec {Echo Request}
  |               |               |               |               | (Packet #6) (Judgment #5)
  |---------------+===============+===============+-------------->| IPsec {Echo Reply}
  |               |               |               |               | (Packet #7) (Judgment #6)
  |               |               |               |               |
  V               V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

| | |
|---|---|
| Packet #5 | See below |
| Packet #6 | See Common Packet #21 |
| Packet #7 | See Common Packet #25 |

- Packet #5: cryptographicaly unprotected INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link A |
| | Destination Address | NUT's Global Address on Link X |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 41 (N) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | any |
| | Length | any |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 0 |
| | Notify Message Type | 11 (INVALID_SPI) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1 and TN1 forwards the Echo Request with IPsec ESP using corresponding algorithms to the NUT.
6. Observe the messages transmitted on Link A.
7. After reception of an Echo Request from the NUT, TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TR1 transmit a cryptographically unprotected INFORMATIONAL request with Notify payload of type INVALID_ SPI to the NUT.
10. TH2 transmits an Echo Request to TH1 and TN1 forwards the Echo Request with IPsec ESP using corresponding algorithms to the NUT.
11. Observe the messages transmitted on Link A.
12. After reception of an Echo Request from the NUT, TH1 transmits an Echo Reply to TH2.
13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 11: Judgment #5**
The NUT forwards an Echo Request.

**Step 13: Judgment #6**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None

## Test IKEv2.SGW.R.1.1.3.3: Close connections when receiving INITIAL_CONTACT

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.3.4: Receiving Liveness check

**Purpose:**

To verify an IKEv2 device checks whether the other endpoint is alive.

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  |<---------------| INFORMATIONAL request (HDR, SK {})
  |                | (Packet #3)
  |--------------->| INFORMATIONAL response (HDR, SK {})
  |                | (Judgment #3)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #17 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

## Test IKEv2.SGW.R.1.1.3.5: Receiving Delete Payload for IKE_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when IKE_SA is deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  |<---------------| INFORMATIONAL request (HDR, SK {D})
  |                | (Packet #3)
  |--------------->| INFORMATIONAL response (HDR, SK {})
  |                | (Judgment #3)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |

| | | |
|---|---|---|
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 2 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Protocol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index | none |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with a Delete payload including 1 (IKE_SA) as Protocol ID, zero as SPI Size and no SPI value.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with no payloads.

**Possible Problems:**

- None

## Test IKEv2.SGW.R.1.1.3.6: Receiving Delete Payload for CHILD_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when CHILD_SAs are deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT            TN1
(SGW)          (SGW)
  |              |
  |<-------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |              |  (Packet #1)
  |------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |              |  (Judgment #1)
  |              |
  |<-------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |              |  (Packet #2)
  |------------->|  IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |              |  (Judgment #2)
  |              |
  |<-------------|  INFORMATIONAL request (HDR, SK {D})
  |              |  (Packet #3)
  |------------->|  INFORMATIONAL response (HDR, SK {D})
  |              |  (Judgment #3)
  |              |
  V              V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |

| | | |
|---|---|---|
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 2 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value to be deleted |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with a Delete payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the TN1's inbound SPI value to be deleted as SPI value.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response with a Delete payload including 3 (ESP) as Protocol ID, 4 as SPI Size and the NUT's inbound SPI value to be deleted as SPI value.

**Possible Problems:**

- None

## Group 1.4. Version Numbers and Forward Compatibility

### Test IKEv2.SGW.R.1.1.4.1: Receipt of a higher minor version number

**Purpose:**

To verify an IKEv2 device drops a message with a higher minor version number and send a notification message.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  V                V
```

| | |
|---|---|
| Packet #1 | See below |

- Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Other fields are same as the Common Packet #1 | |
| | Major Version | 2 |
| | Minor Version | 1 |
| SA Payload | Same as the Common Packet #1 | |
| KE Payload | Same as the Common Packet #1 | |
| Ni, Nr Payload | Same as the Common Packet #1 | |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request with a higher minor version number.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.4.2: Receipt of a higher major version number

**Purpose:**

To verify an IKEv2 device drops a message with a higher major version number and send a notification message.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, N(INVALID_MAJOR_VERSION))
   |                | (Judgment #1)
   |                |
   V                V
```

| | |
|---|---|
| Packet #1 | See below |

Packet#1:

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Other fields are same as the Common Packet #1 | |
| | Major Version | 3 |
| SA Payload | Same as the Common Packet #1 | |
| KE Payload | Same as the Common Packet #1 | |
| Ni Payload | Same as the Common Packet #1 | |

*Part A: (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an INFORMATIONAL response with a Notify payload of type INVALID_MAJOR_VERSION containing following values:

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Protocol ID  !   SPI Size    !      Notify Message Type      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                Security Parameter Index (SPI)                 ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       Notification Data                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 159 Notify Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A SPI Size field set to zero.
- A Notify Message Type field set to INVALID_MAJOR_VERSION (5).
- A Notification Data field set to the highest version number it supports (2).

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.4.3: Unrecognized payload types and critical bit is not set

**Purpose:**

To verify an IKEv2 device ignores invalid payload types when the invalid type payload’s critical bit is not set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Judgment #1)
   |                |
   |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                | (Packet #2)
   |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                | (Judgment #2)
   |                |
   |<---------------| CREATE_CHILD_SA request (HDR, SK {P, N, SA, Ni, TSi, TSr})
   |                | (Packet #3)
   |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
   |                | (Judgment #3)
   |                |
   V                V

P: Payload with an invalid payload type
N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #15 Payload | |
| UDP Header | All fields are same as Common Packet #15 Payload | |
| IKEv2 Header | All fields are same as Common Packet #15 Payload | |
| E Payload | Next Payload | *Invalid payload type value* |

| | | |
|---|---|---|
| | Other fields are same as Common Packet #15 | |
| Invalid Payload | Next Payoad | 41 (N) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 4 |
| N Payload | All fields are same as Common Packet #15 Payload | |
| SA Payload | All fields are same as Common Packet #15 Payload | |
| Ni, Nr Payload | All fields are same as Common Packet #15 Payload | |
| TSi Paylaod | All fields are same as Common Packet #15 Payload | |
| TSr Payload | All fields are same as Common Packet #15 Payload | |

*Part A: Invalid payload type 1 (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 1 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 32 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 49 and the invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits a CREATE_CHILD_SA request including a payload with invalid payload type to the NUT. The E payload's IKE Header Next Payload field is set to 255 and the

invalid payload's critical flag is not set. The request includes a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.

24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.4.4: Unrecognized payload types and critical bit is set

**Purpose:**

To verify an IKEv2 device ignores invalid payload types when the invalid type payload's critical bit is set.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT             TN1
 (SGW)           (SGW)
   |               |
   |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |               | (Packet #1)
   |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |               | (Judgment #1)
   |               |
   |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |               | (Packet #2)
   |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |               | (Judgment #2)
   |               |
   |<--------------| CREATE_CHILD_SA request (HDR, SK {N, P, SA, Ni, TSi, TSr})
   |               | (Packet #3)
   |-------------->| CREATE_CHILD_SA response (HDR, SK {N(UNSUPPORTED_CRITICAL_PAYLOAD)})
   |               | (Judgment #3)
   |               |
   V               V

P: Payload with an invalid payload type
N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | All fields are same as Common Packet #13 Payload | |
| UDP Header | All fields are same as Common Packet #13 Payload | |
| IKEv2 Header | All fields are same as Common Packet #13 Payload | |
| E Payload | All fields are same as Common Packet #13 Payload | |
| N Payload | Next Payoad | *Invalid payload type value* |

| | | |
|---|---|---|
| | Other fields are same as Common Packet #13 | |
| Invalid Payload | Next Payoad | 33 (SA) |
| | Critical | 1 |
| | Reserved | 0 |
| | Payload Length | 4 |
| SA Payload | All fields are same as Common Packet #13 Payload | |
| Ni, Nr Paylaod | All fields are same as Common Packet #13 Payload | |
| TSi Paylaod | All fields are same as Common Packet #13 Payload | |
| TSr Payload | All fields are same as Common Packet #13 Payload | |

*Part A: Invalid payload type 1 and Critical bit is set (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 1 and the pointed pyaload's Critical bit is set.
6. Observe the messages transmitted on Link A.

*Part B: Invalid payload type 32 and Critical bit is set (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 32 and the pointed pyaload's Critical bit is set.
12. Observe the messages transmitted on Link A.

*Part C: Invalid payload type 49 and Critical bit is set (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload invalid payload type to the NUT. The CREATE_CHILD_SA request's IKE Header Next Payload field is set to 49 and the pointed pyaload's Critical bit is set.
18. Observe the messages transmitted on Link A.

*Part D: Invalid payload type 255 and Critical bit is set (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH response from the NUT, TN1 transmits a CREATE_CHILD_SA request including a payload invalid payload type to the NUT. The

CREATE_CHILD_SA request's IKE Header Next Payload field is set to 255 and the pointed pyaload's Critical bit is set.

24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (1).

*Part B*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (32).

*Part C*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (49).

*Part D*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response. The response has a Notify payload of type UNSUPPORTED_CRITICAL_PAYLOAD with the invalid payload type value (255).

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.4.5: Invalid Order Payloads

**Purpose:**

To verify an IKEv2 device properly handles IKE message with invalid order payloads.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, Ni, KEi)
  |                | (Packet #1)
  |-------X        | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>KEi payload and Ni payload replace each other. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT never transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Group 1.5. Cookies

### Test IKEv2.SGW.R.1.1.5.1: Cookies

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.5.2: Invalid Cookies

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.5.3: Interaction of COOKIE and INVALID_KE_PAYLOAD

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.5.4: Interaction of COOKIE and INVALID_KE_PAYLOAD with unoptimized Initiator

This test case was deleted at revision 1.1.0.

## Group 1.6. Cryptographic Algorithm Negotiation

### Test IKEv2.SGW.R.1.1.6.1: Cryptographic Algorithm Negotiation for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  From part A to part H, configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ***ENCR_AES_CBC*** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | DELETED | DELETED | DELETED | DELETED |
| **Part C** | ENCR_3DES | ***PRF_AES128_CBC*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_AES_XCBC_96*** | Group 2 |
| **Part E** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 14*** |
| **Part F** | ENCR_3DES | ***PRF_HMAC_SHA2_256*** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part G** | ENCR_3DES | PRF_HMAC_SHA1 | ***AUTH_HMAC_SHA2_256_128*** | Group 2 |
| **Part H** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | ***Group 24*** |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See below |

| | |
|---|---|
| Packet #2 | See Common Packet #5 |

Packet #1: IKE_SA_INIT request

Packet #1 is same as Common Packet #1 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part B:

This test case is deleted at revision 1.0.4.

Part C:

SA Transform of Tranform Type PRF is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (AES128_XCBC) |

Part D:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 5 (AES_XCBC_96) |

Part E:

SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 4 (D-H) |
| | Reserved | 0 |
| | Transform ID | 14 (2048 MODP Group) |

Part F:

SA Transform of Tranform Type PRF is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 5 (HMAC_SHA2_256) |

Part G:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Transform ID | 12 (HMAC_SHA2_256_128) |

Part H:
SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 4 (D-H) |
| | Reserved | 0 |
| | Transform ID | 24 (2048-bit MODP Group with 256-bit Prime Order Subgroup) |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

This test case was deleted at revision 1.1.0.

*Part C: PRF PRF_AES128_CBC (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
12. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
16. Observe the messages transmitted on Link A.

*Part E: D-H Group Group 14 (ADVANCED)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
20. Observe the messages transmitted on Link A.

*Part F: PRF PRF_HMAC_SHA2_256 (ADVANCED)*

21. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
24. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
28. Observe the messages transmitted on Link A.

*Part H: D-H Group Group 24 (ADVANCED)*

29. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
30. Observe the messages transmitted on Link A.
31. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request protected with the accepted proposal to the NUT.
32. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_AES_CBC", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

This test case was deleted at revision 1.1.0.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_AES128_CBC", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part D*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as accepted algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part F*

**Step 22: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA2_256", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 24: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA2_256_128" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part H*

**Step 30: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 24" as accepted algorithms.

**Step 32: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.2: Cryptographic Algorithm Negotiation for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-Shared key.

**References:**

- [RFC 4306] - Sections 2.7 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

  From part A to part G, TN1 transmits an IKE_AUTH request including a SA payload which contains the transforms as follows:

| | IKE_AUTH exchanges Algorithms | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **Extended Sequence Numbers** |
| **Part A** | *ENCR_AES_CBC* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part B** | *ENCR_AES_CTR* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part C** | *ENCR_NULL* | AUTH_HMAC_SHA1_96 | No Extended Sequence Numbers |
| **Part D** | ENCR_3DES | *AUTH_AES_XCBC_96* | No Extended Sequence Numbers |
| **Part E** | ENCR_3DES | *NONE* | No Extended Sequence Numbers |
| **Part F** | ENCR_3DES | AUTH_HMAC_SHA1_96 | *Extended Sequence Numbers* |
| **Part G** | ENCR_3DES | ***AUTH_HMAC_SHA2_256_128*** | No Extended Sequence Numbers |

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |<--------------|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Packet #1)
  |               |-------------->|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Judgment #1)
  |               |               |               |
  |               |<--------------|               | IKE_AUTH request (HDR, SK {IDi, AUTH, N, SAi2,
  |               |               |               |                            TSi, TSr})
  |               |               |               | (Packet #2)
  |               |-------------->|               | IKE_AUTH response (HDR, SK {IDr, AUTH, N, SAr2,
  |               |               |               |                             TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

Packet #2: IKE_AUTH request

Packet #2 is same as Common Packet #5 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part B:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | | |
|---|---|---|---|
| SA Transform | Next Payload | | 3 (more) |
| | Reserved | | 0 |
| | Transform Length | | 8 |
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 13 (AES_CTR) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

Part C:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 1 (ENCR) |
| | Reserved | 0 |
| | Transform ID | 11 (ENCR_NULL) |

Part D:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 5 (AES_XCBC_96) |

Part E:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Transform ID | 0 (NONE) |

Part F:

SA Transform of Tranform Type ESN is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 5 (ESN) |
| | Reserved | 0 |
| | Transform ID | 1 (Extended Sequence Numbers) |

Part G:

SA Transform of Tranform Type INTEG is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 3 (INTEG) |
| | Reserved | 0 |
| | Transform ID | 12 (HMAC_SHA2_256_128) |

*Part A: Encryption Algorithm ENCR_AES_CBC (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.

*Part B: Encryption Algorithm ENCR_AES_CTR (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

*Part C: Encryption Algorithm ENCR_NULL (ADVANCED)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
20. Observe the messages transmitted on Link A.
21. TH2 transmits an Echo Request to TH1.
22. Observe the messages transmitted on Link B.
23. TH1 transmits an Echo Reply to TH2.
24. Observe the messages transmitted on Link A.

*Part D: Integrity Algorithm AUTH_AES_XCBC_96 (ADVANCED)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
28. Observe the messages transmitted on Link A.
29. TH2 transmits an Echo Request to TH1.
30. Observe the messages transmitted on Link B.
31. TH1 transmits an Echo Reply to TH2.
32. Observe the messages transmitted on Link A.

*Part E: Integrity Algorithm NONE (ADVANCED)*

33. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
34. Observe the messages transmitted on Link A.
35. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
36. Observe the messages transmitted on Link A.
37. TH2 transmits an Echo Request to TH1.
38. Observe the messages transmitted on Link B.
39. TH1 transmits an Echo Reply to TH2.
40. Observe the messages transmitted on Link A.

*Part F: Extended Sequence Numbers (ADVANCED)*

41. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
42. Observe the messages transmitted on Link A.
43. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
44. Observe the messages transmitted on Link A.
45. TH2 transmits an Echo Request to TH1.
46. Observe the messages transmitted on Link B.
47. TH1 transmits an Echo Reply to TH2.
48. Observe the messages transmitted on Link A.

*Part G: Integrity Algorithm AUTH_HMAC_SHA2_256_128 (ADVANCED)*

49. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
50. Observe the messages transmitted on Link A.
51. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request as described above to the NUT.
52. Observe the messages transmitted on Link A.
53. TH2 transmits an Echo Request to TH1.
54. Observe the messages transmitted on Link B.
55. TH1 transmits an Echo Reply to TH2.
56. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_AES_CBC", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part B*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_AES_CTR", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 14: Judgment #3**
The NUT forwards an Echo Request.

**Step 16: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part C*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_NULL", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 22: Judgment #3**
The NUT forwards an Echo Request.

**Step 24: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part D*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_AES_XCBC_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 30: Judgment #3**
The NUT forwards an Echo Request.

**Step 32: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part E*

**Step 34: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 36: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "NONE" and "No Extended Sequence Numbers" as accepted algorithms. However, the transform indicating "NONE" can be omitted.

**Step 38: Judgment #3**
The NUT forwards an Echo Request.

**Step 40: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part F*

**Step 42: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 44: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "Extended Sequence Numbers" as accepted algorithms.

**Step 46: Judgment #3**
The NUT forwards an Echo Request.

**Step 48: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

*Part G*

**Step 50: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 52: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA2_256_128" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 54: Judgment #3**
The NUT forwards an Echo Request.

**Step 56: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.3: Receiving Multiple Transforms for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT request with an multiple transforms payload.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |<-----------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |  (Packet #1)
  |----------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |  (Judgment #1)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See below |

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the transforms as follows:

| | **IKE_SA_INIT exchanges Algorithms** | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_AES_CBC ENCR_3DES** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_AES128_CBC PRF_HMAC_SHA1** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96 AUTH_HMAC_SHA1_96** | Group 2 |
| **Part D** | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or Group 24, Group 2** |

- Packet #1 IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Same as the Common Packet #1 | |
| SA Payload | Other fields are same as the common packet #1 | |
| | SA Proposals | See SA Table below |

| | |
|---|---|
| KE Payload | Same as the Common Packet #1 |
| Ni, Nr Payload | Same as the Common Packet #1 |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
6. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.

8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

# Test IKEv2.SGW.R.1.1.6.4: Receiving Multiple Proposals for IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT request with multiple proposals.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                 TN1
(SGW)               (SGW)
  |                   |
  |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   | (Packet #1)
  |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   | (Judgment #1)
  |                   |
  V                   V
```

Packet #1 See below

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the proposals as follows:

| | IKE_SA_INIT exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | Proposals | Protocol ID | Encryption | PRF | Integrity | D-H Group |
| Part A | Proposal #1 | IKE | **ENCR_AES_CBC** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part B | Proposal #1 | IKE | ENCR_3DES | **PRF_AES128_CBC** | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part C | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96** | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part D | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or Group 24** |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

- Packet #1 IKE_SA_INIT request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #1 |
| UDP Header | Same as the Common Packet #1 |
| IKEv2 Header | Same as the Common Packet #1 |
| SA Payload | Other fields are same as the common packet #1 |

| | | |
|---|---|---|
| | SA Proposals | See SA Table below |
| KE Payload | Same as the Common Packet #1 | |
| Ni, Nr Payload | Same as the Common Packet #1 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 2 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
2. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo-Random Functions (BASIC)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
4. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
6. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Groups (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload as described above.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

*Part D*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.5: Receiving Multiple Transforms for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles IKE_SA_INIT request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

From part A to part D, TN1 transmits an IKE_AUTH request including a SA payload which contains the transforms as follows:

| | **IKE_AUTH exchanges Algorithms** | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_AES_CBC**<br>**ENCR_3DES** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_AES_XCBC_96**<br>**AUTH_HMAC_SHA1_96** | No ESN |
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **ESN**<br>**No ESN** |

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

- Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #5 |

| | | | |
|---|---|---|---|
| UDP Header | Same as the Common Packet #5 | | |
| IKEv2 Header | Same as the Common Packet #5 | | |
| E Payload | Same as the Common Packet #5 | | |
| IDi Payload | Same as the Common Packet #5 | | |
| AUTH Payload | Same as the Common Packet #5 | | |
| SA Payload | Other fields are Same as the Common Packet #5 | | |
| | SA Proposals | See below | |
| TSi Payload | Same as the Common Packet #5 | | |
| TSr Payload | Same as the Common Packet #5 | | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.

10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.6: Receiving Multiple Proposals for CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles CHILD_SA request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #1)
  |               |
  |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               | (Packet #2)
  |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               | (Judgment #2)
  |               |
  V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

TN1 transmits an IKE_AUTH request including a SA payload which contains the two proposals as follows:

| | IKE_AUTH exchanges Algorithms | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | **ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | Proposal #1 | ESP | ENCR_3DES | **AUTH_AES_XCBC_96** | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part C** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | **ESN** |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Same as the Common Packet #5 | |
| AUTH Payload | Same as the Common Packet #5 | |
| SA Payload | Other fields are Same as the Common Packet #5 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #5 | |
| TSr Payload | Same as the Common Packet #5 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 2 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request including a SA payload as described above to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH response including a SA Proposal with "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.7: Sending INVALID_KE_PAYLOAD

**Purpose:**

To verify an IKEv2 device properly handles a KE payload which has different D-H Group # from accepted D-H Group #.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration. Enable PFS.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                TN1
  (SGW)              (SGW)
    |                  |
    |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Packet #1)
    |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Judgment #1)
    |                  |
    |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                  | (Packet #2)
    |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    |<-----------------| CREATE_CHILD_SA request (HDR, SK {N, SA(DH#2, DH#14), Ni, KEi(DH#14), TSi, TSr})
    |                  | (Packet #3)
    |----------------->| CREATE_CHILD_SA response (HDR, SK { N(INVALID_KE_PAYLOAD(DH#2))})
    |                  | (Judgment #3)
    |                  |
    |<-----------------| CREATE_CHILD_SA request (HDR, SK {N, SA(DH#2, DH#14), Ni, KEi(DH#2), TSi, TSr})
    |                  | (Packet #4)
    |----------------->| CREATE_CHILD_SA response (HDR, SK {SA(DH#2), Nr, KEr(DH#2), TSi, TSr})
    |                  | (Judgment #4)
    V                  V

N: REKEY_SA
It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |
| Packet #4 | See below |

Packet #3: CREATE_CHILD_SA request for rekeying CHILD_SA

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Other fields are same as the Common Packet #15 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Other fields are same as the Common Packet #15 | |
| | Next Payload | 34 (KE) |
| KEi Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 264 |
| | DH Group # | 14 |
| | Reserved | 0 |
| | Key Exchange Data | DH#14 public key value |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

SA Payloads

| | | | |
|---|---|---|---|
| SA Proposal | Next Payload | | 0 (last) |
| | Reserved | | 0 |
| | Proposal Length | | 48 |
| | Proposal # | | 1 |
| | Protocol ID | | 1 (IKE) |
| | SPI Size | | 0 |
| | # of Transforms | | 5 |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 1 (ENCR) |
| | | Reserved | 0 |
| | | Transform ID | 3 (3DES) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 2 (PRF) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 3 (INTEG) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1_96) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 2 (1024 MODP Group) |
| | SA Transform | Next Payload | 0 (last) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 14 (2048 MODP Group) |

Packet #4: CREATE_CHILD_SA request for rekeying CHILD_SA

| | |
|---|---|
| IPv6 Header | Other fields are same as the Common Packet #15 |
| UDP Header | Other fields are same as the Common Packet #15 |
| IKEv2 Header | Other fields are same as the Common Packet #15 |
| E Payload | Other fields are same as the Common Packet #15 |

| | | |
|---|---|---|
| N Payload | Other fields are same as the Common Packet #15 | |
| SA Payload | Same as Packet #3 | |
| Ni, Nr Payload | Other fields are same as the Common Packet #15 | |
| | Next Payload | 34 (KE) |
| KEi Payload | Other fields are same as the Packet #3 | |
| | DH Group # | 2 |
| | Key Exchange Data | DH#2 public key value |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs. The CREATE_CHILD_SA contains a D-H Group transform to use D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 14 (D-H Group 14) as DH Group # field and the Key Exchage Data. It is possible to use D-H Group 24 instead of D-H Group 14.
6. Observe the messages transmitted on Link A.
7. After reception of CREATE_CHILD_SA response indicating INVALID_KE_PAYLOAD from the NUT, TN1 retransmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs. The CREATE_CHILD_SA contains a D-H Group transform to use D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 2 (D-H Group 2) as DH Group # field and the Key Exchage Data. It is possible to use D-H Group 24 instead of D-H Group 14.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type INVALID_KE_PAYLOAD which contains 2 (D-H Group 2) as Notification Data.

**Step 8: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96", "No Extended Sequence Numbers" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.8: Sending INVALID_KE_PAYLOAD in Initial Exchange

**Purpose:**

To verify an IKEv2 device properly handles KE payload which has different D-H Group # from accepted D-H Group #.

**References:**

- [RFC 4306] - Sections 2.7, 3.4 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT               TN1
 (SGW)             (SGW)
   |                 |
   |<----------------| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#14), Ni)
   |                 | (Packet #1)
   |---------------->| IKE_SA_INIT response (HDR, N(INVALID_KE_PAYLOAD(DH#2)))
   |                 | (Judgment #1)
   |                 |
   |<----------------| IKE_SA_INIT request (HDR, SAi1(DH#2, DH#14), KEi(DH#2), Ni)
   |                 | (Packet #2)
   |---------------->| IKE_SA_INIT response (HDR, SAr1(DH#2), KEr(DH#2), Nr)
   |                 | (Judgment #2)
   |                 |
   V                 V

It is possible to use DH#24 instead of DH#14.
```

| | |
|---|---|
| Packet #1 | See below |
| Packet #2 | See Common packet #1 |

Packet #1: IKE_SA_INIT request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #1 | |
| UDP Header | Same as the Common Packet #1 | |
| IKEv2 Header | Same as the Common Packet #1 | |
| SA Payload | Other fields are same as the common packet #1 | |
| | SA Proposals | See SA Table below |
| KEi Payload | Other fields are same as the common packet #1 | |
| | DH Group # | 14 |
| | Key Exchange Data | DH#14 public key value |
| Ni, Nr Payload | Same as the Common Packet #1 | |

SA Payloads

| | | | |
|---|---|---|---|
| SA Proposal | Next Payload | | 0 (last) |
| | Reserved | | 0 |
| | Proposal Length | | 48 |
| | Proposal # | | 1 |
| | Protocol ID | | 1 (IKE) |
| | SPI Size | | 0 |
| | # of Transforms | | 5 |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 1 (ENCR) |
| | | Reserved | 0 |
| | | Transform ID | 3 (3DES) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 2 (PRF) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 3 (INTEG) |
| | | Reserved | 0 |
| | | Transform ID | 2 (HMAC_SHA1_96) |
| | SA Transform | Next Payload | 3 (more) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 2 (1024 MODP Group) |
| | SA Transform | Next Payload | 0 (last) |
| | | Reserved | 0 |
| | | Transform Length | 8 |
| | | Transform Type | 4 (D-H) |
| | | Reserved | 0 |
| | | Transform ID | 14 (2048 MODP Group) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request including a SA payload which contains a D-H Group transform proposes using D-H Group 2 and D-H Group 14, and a Key Exchange payload which contains 14 (D-H Group 14) as DH Group # field and the Key Exchange Data. It is possible to use D-H Group 24 instead of D-H Group 14.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including a Notify payload of type INVALID_KE_PAYLOAD which contains 2 (D-H Group 2) as Notification Data. The message's IKE_SA Responder's SPI value is set to zero.

**Step 4: Judgment #2**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.6.9: Creating an IKE_SA without a CHILD_SA

**Purpose:**

To verify that an IKEv2 device can handles a failure of creating a CHILD_SA during the IKE_AUTH exchange.

**References:**

- [RFC 4718] - Sections 4.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #1)
  |               |
  |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               | (Packet #2)
  |-------------->| IKE_AUTH response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
  |               | (Judgment #2)
  |               |
  |<--------------| INFORMATIONAL request (HDR, SK {})
  |               | (Packet #3)
  |-------------->| INFORMATIONAL response (HDR, SK {})
  |               | (Judgment #3)
  |               |
  V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #17 |

Packet #2: IKE_AUTH request

Packet #2 is same as Common Packet  #5 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type ENCR is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 3 (more) |
| | Reserved | 0 |
| | Transform Length | 8 |

| | | | |
|---|---|---|---|
| | Transform Type | | 1 (ENCR) |
| | Reserved | | 0 |
| | Transform ID | | 12 (AES_CBC) |
| | SA Attribute | Attribute Type | 14 (Key Length) |
| | | Attribute Value | 128 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH request with unacceptable SA proposal for the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with no payloads.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including a Notify type of NO_PROPOSAL_CHOSEN.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

# Group 1.7. Traffic Selector Negotiation

## Test IKEv2.SGW.R.1.1.7.1: Narrowing Traffic Selectors

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

<table>
<tr><th rowspan="3"></th><th colspan="6">Traffic Selector</th></tr>
<tr><th colspan="3">Source</th><th colspan="3">Destination</th></tr>
<tr><th>Address Range</th><th>Next Layer Protocol</th><th>Port Range</th><th>Address Range</th><th>Next Layer Protocol</th><th>Port Range</th></tr>
<tr><th>Inbound</th><td>TH2</td><td>ANY</td><td>ANY</td><td>NUT</td><td>ANY</td><td>ANY</td></tr>
<tr><th>Outbound</th><td>NUT</td><td>ANY</td><td>ANY</td><td>TH2</td><td>ANY</td><td>ANY</td></tr>
</table>

The other packets are allowed to BYPASS IPsec protection.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  TH1             NUT             TN1             TH2             TH3
 (Host)          (SGW)           (SGW)          (Host)          (Host)
    |               |               |               |               |
    |               |<--------------|               |               | IKE_SA_INIT request (HDR, SAi1,
    |               |               |               |               |                     KEi, Ni)
    |               |               |               |               | (Packet #1)
    |               |-------------->|               |               | IKE_SA_INIT response (HDR, SAr1,
    |               |               |               |               |                      KEr, Nr)
    |               |               |               |               | (Judgment #1)
    |               |               |               |               |
    |               |<--------------|               |               | IKE_AUTH request (HDR, SK {IDi, AUTH,
    |               |               |               |               |                 SAi2, TSi, TSr})
    |               |               |               |               | (Packet #2)
    |               |-------------->|               |               | IKE_AUTH response (HDR, SK {IDr, AUTH,
    |               |               |               |               |                  SAr2, TSi, TSr})
    |               |               |               |               | (Judgment #2)
    |               |               |               |               |
    |<--------------+===============+---------------|               | IPsec {Echo Request}
    |               |               |               |               | (Packet #3) (Judgment #3)
    |---------------+===============+-------------->|               | IPsec {Echo Reply}
    |               |               |               |               | (Packet #4) (Judgment #4)
    |               |               |               |               |
    |       X-------+===============+-------------------------------| IPsec {Echo Request}
    |               |               |               |               | (Packet #5) (Judgment #5)
    |-------------------------------------------------------------->| IPsec {Echo Reply}
    |               |               |               |               | (Packet #6) (Judgment #6)
    |               |               |               |               |
    V               V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |

- Packet #5: ICMPv6 Echo Request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #21 | |
| ESP | Same as the Common Packet #21 | |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Same as the Common Packet #21 | |

- Packet #6: ICMPv6 Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | TH3's Global Address |
| ICMPv6 Header | Same as the Common Packet #25 | |

*Part A (BASIC)*

1. TN1 sends an IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 sends an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request packet to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply packet to TH2.

8. Observe the messages transmitted on Link A.
9. TH3 transmits an Echo Request to TH1.
10. Observe the messages transmitted on Link B.
11. TH1 transmits an Echo Request to TH3.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. The Traffic Selector is narrowed to allow only address range of TH2.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Request with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT never forwards an Echo Request.

**Step 12: Judgment #6**
The NUT forwards an Echo Request without IPsec ESP.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TH2 can send Echo Reply to TH1 instead of sending Echo Request.

## Test IKEv2.SGW.R.1.1.7.2: TS_UNACCEPTABLE

**Purpose:**

To verify an IKEv2 device properly handles the Traffice Selector.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TH2 | ANY | ANY | NUT | ANY | ANY |
| **Outbound** | NUT | ANY | ANY | TH2 | ANY | ANY |

  The other packets are allowed to BYPASS IPsec protection.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Judgment #1)
   |                |
   |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                | (Packet #2)
   |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                | (Judgment #2)
   |                |
   |<---------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, KEi, TSi, TSr})
   |                | (Packet #3)
   |--------------->| CREATE_CHILD_SA response (HDR, SK {N(TS_UNACCEPTABLE)})
   |                | (Judgment #3)
   V                V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Same as the Common Packet #5 | |
| AUTH Payload | Same as the Common Packet #5 | |
| N Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH2's Global Address on Link X |
| | | Ending Address | TH2's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #9 | |
| UDP Header | Same as the Common Packet #9 | |
| IKEv2 Header | Same as the Common Packet #9 | |
| E Payload | Same as the Common Packet #9 | |
| SA Payload | Same as the Common Packet #9 | |
| Ni, Nr Payload | Same as the Common Packet #9 | |
| TSi Payload | Other fields are same as the Common Packet #9 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #9 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH3's Global Address on Link X |
| | | Ending Address | TH3's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

*Part A (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request including ICMPv6 (58) as IP Protocol ID value in Traffic Selector Payload.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type TS_UNACCEPTABLE.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.7.3: Narrowing Traffic Selectors

**Purpose:**

To verify an IKEv2 device allows the responder to choose a subset of the traffic proposed by the initiator.

**References:**

- [RFC4306] - Section 2.8
- [RFC4718] - Section 4.10

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration except Traffic Selector. Traffic Selector should be configured as following.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TH2 | ANY | ANY | NUT | ANY | ANY |
| **Outbound** | NUT | ANY | ANY | TH2 | ANY | ANY |

The other packets are allowed to BYPASS IPsec protection.

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                  NUT                 TN1                 TH2                 TH3
(Host)               (SGW)               (SGW)               (Host)              (Host)
 |                    |                   |                   |                   |
 |                    |<------------------|                   |                   | IKE_SA_INIT request (HDR, SAi1,
 |                    |                   |                   |                   |                       KEi, Ni)
 |                    |                   |                   |                   | (Packet #1)
 |                    |------------------>|                   |                   | IKE_SA_INIT response (HDR, SAr1,
 |                    |                   |                   |                   |                       KEr, Nr)
 |                    |                   |                   |                   | (Judgment #1)
 |                    |                   |                   |                   |
 |                    |<------------------|                   |                   | IKE_AUTH request (HDR, SK {IDi, AUTH,
 |                    |                   |                   |                   |                 SAi2, TSi, TSr})
 |                    |                   |                   |                   | (Packet #2)
 |                    |------------------>|                   |                   | IKE_AUTH response (HDR, SK {IDr, AUTH,
 |                    |                   |                   |                   |                 SAr2, TSi, TSr})
 |                    |                   |                   |                   | (Judgment #2)
 |                    |                   |                   |                   |
 |<-------------------+===================+-------------------|                   | IPsec {Echo Request}
 |                    |                   |                   |                   | (Packet #3) (Judgment #3)
 |--------------------+===================+------------------>|                   | IPsec {Echo Reply}
 |                    |                   |                   |                   | (Packet #4) (Judgment #4)
 |                    |                   |                   |                   |
 |          X---------+===================+---------------------------------------| IPsec {Echo Request}
 |                    |                   |                   |                   | (Packet #5) (Judgment #5)
 |-------------------------------------------------------------------------------->| IPsec {Echo Reply}
 |                    |                   |                   |                   | (Packet #6) (Judgment #6)
 |                    |                   |                   |                   |
 V                    V                   V                   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Same as the Common Packet #5 | |
| AUTH Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH2's Global Address on Link X |
| | | Ending Address | TH2's Global Address on Link X |
| | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |

| | | | |
|---|---|---|---|
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH3's Global Address on Link X |
| | | Ending Address | TH3's Global Address on Link X |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH1's Global Address on Link A |
| | | Ending Address | TH1's Global Address on Link A |

- Packet #5: ICMPv6 Echo Request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #21 | |
| ESP | Same as the Common Packet #21 | |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Same as the Common Packet #21 | |

- Packet #6: ICMPv6 Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Destination Address | TH3's Global Address |
| ICMPv6 Header | Same as the Common Packet #25 | |

*Part A (BASIC)*

1. TN1 sends an IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. TN1 sends an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request packet to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply packet to TH2.
8. Observe the messages transmitted on Link A.
9. TH3 transmits an Echo Request to TH1.
10. Observe the messages transmitted on Link B.
11. TH1 transmits an Echo Request to TH3.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. The Traffic Selector is narrowed to allow the traffic from/to TH2.

**Step 6: Judgment #3**

The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Request with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT never forwards an Echo Request.

**Step 12: Judgment #6**
The NUT forwards an Echo Request without IPsec ESP.

**Possible Problems:**

- Because the destination address of  Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TH2 can send Echo Reply to TH1 instead of sending Echo Request.

## Group 1.8. Error Handling

### Test IKEv2.SGW.R.1.1.8.1: INVALID_IKE_SPI

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.8.2: INVALID_SYNTAX

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.1.8.3: INVALID_SELECTORS

This test case was deleted at revision 1.1.0.

# Group 1.10 Authentication of the IKE_SA

## Test IKEv2.SGW.R.1.1.10.1: Sending Certificate Payload

**Purpose:**

To verify an IKEv2 device handles a CERTREQ payload and transmits a CERT payload propoerly.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Local | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | NUT's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | nut.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | nut@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                   TN1
  (SGW)                 (SGW)
    |                     |
    |<--------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                     | (Packet #1)
    |-------------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                     | (Judgment #1)
    |                     |
    |<--------------------| IKE_AUTH request (HDR, SK {IDi, CERTREQ, AUTH, SAi2, TSi, TSr})
    |                     | (Packet #2)
    |-------------------->| IKE_AUTH response (HDR, SK {IDr, CERT, AUTH, SAr2, TSi, TSr})
    |                     | (Judgment #2)
    |                     |
    V                     V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

- Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | Same as the Common Packet #5 |

| | | |
|---|---|---|
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Next Payload | 38 (CERTREQ) |
| | Oter fields are same as the Common Packet #5 | |
| CERTREQ Payload | See below | |
| AUTH Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Same as the Common Packet #5 | |
| TSr Payload | Same as the Common Packet #5 | |

| | | |
|---|---|---|
| CERTREQ Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Authority | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
4. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.
7. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
8. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a CERTREQ payload to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_IPV6_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT's certificate as Certificate Data.

*Part B*

**Step 6: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_FQDN and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

*Part C*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response. The response includes an ID payload with ID_RFC822_ADDR and a CERT payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding and the NUT’s certificate as Certificate Data.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.10.2: Sending Certificate Request Payload

**Purpose:**

To verify an IKEv2 device properly transmits CERTREQ payload.

**References:**

- [RFC 4306] - Sections 1.2 and 3.7

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1's global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                  TN1
(SGW)                (SGW)
  |                    |
  |<-------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                    | (Packet #1)
  |------------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
  |                    | (Judgment #1)
  |                    |
  V                    V
```

| Packet #1 | See Common Packet #1 |
|---|---|

*Part A:ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

*Part B:ID_FQDN (ADVANCED)*

3. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
4. Observe the messages transmitted on Link A.

*Part C:ID_RFC822_ADDR (ADVANCED)*

5. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part B*

**Step 4: Judgment #1**
The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

*Part C*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response with a CERTREQ payload which contains 4 (X.509 Certificate - Signature) as Certificate Encoding.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.10.3: RSA Digital Signature

**Purpose:**

To verify an IKEv2 device authenticates the corresponding node by RSA Digital Signature.

**References:**

- [RFC 4306] - Sections 1.2 and 3.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | | Authentication Method | ID Type | ID Data |
|---|---|---|---|---|
| Remote | Part A | X.509 Certificate - Signature | ID_IPV6_ADDR | TN1’s global address on Link A |
| | Part B | X.509 Certificate - Signature | ID_FQDN | tn.example.com |
| | Part C | X.509 Certificate - Signature | ID_RFC822_ADDR | tn@example.com |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1                TH2
(Host)             (SGW)              (SGW)              (Host)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  |                  | (Packet #1)
  |                  |----------------->|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr, CERTREQ)
  |                  |                  |                  | (Judgment #1)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_AUTH request (HDR, SK {IDi, CERT, AUTH,
  |                  |                  |                  |                            SAi2, TSi, TSr})
  |                  |                  |                  | (Packet #2)
  |                  |----------------->|                  | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                  |                  |                  |                             SAr2, TSi, TSr})
  |                  |                  |                  | (Judgment #2)
  |                  |                  |                  |
  |<-----------------+==================+------------------| IPsec {Echo Request}
  |                  |                  |                  | (Packet#3) (Judgment #3)
  |------------------+==================+----------------->| IPsec {Echo Reply}
  |                  |                  |                  | (Packet #4) (Judgment #4)
  |                  |                  |                  |
  V                  V                  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #19 |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Next Payload | 37 (CERT5 |
| | Oter fields are same as the Common Packet #5 | |
| CERT Payload | See below | |
| AUTH Payload | Same as the Common Packet #5 | |
| N Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Same as the Common Packet #5 | |
| TSr Payload | Same as the Common Packet #5 | |

| | | |
|---|---|---|
| CERT Payload | Next Payload | 39 (AUTH) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | Any |
| | Certificate Encoding | 4 (X.509 Certificate – Signature) |
| | Certificate Data | any |

*Part A: ID_IPV6_ADDR (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.

*Part B: ID_FQDN (ADVANCED)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

*Part C: ID_RFC822_ADDR (ADVANCED)*

17. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
18. Observe the messages transmitted on Link A.
19. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with an IDi payload as described above and a CERT payload to the NUT.
20. Observe the messages transmitted on Link A.
21. TH2 transmits an Echo Request to TH1.
22. Observe the messages transmitted on Link B.
23. TH1 transmits an Echo Reply to TH2.
24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part B*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 14: Judgment #3**
The NUT forwards an Echo Request.

**Step 16: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part C*

**Step 18: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 20: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 22: Judgment #3**
The NUT forwards an Echo Request.

**Step 24: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.10.4: HEX string PSK

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key.

**References:**

- [RFC 4306] - Sections 2.15

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the following IKE peer configuration.

| | Authentication Key Value |
|---|---|
| **Local** | 0xabadcafeabadcafeabadcafeabadcafe (128 bit binary string) |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Group 1.11 Invalid values

### Test IKEv2.SGW.R.1.1.11.1: Non zero RESERVED fields in IKE_SA_INIT request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
 (SGW)               (SGW)
   |                   |
   |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Packet #1)
   |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Judgment #1)
   |                   |
   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.11.2: Non zero RESERVED fields in IKE_AUTH request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5<br>All RESERVED fields are set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.11.3: Version bit is set

**Purpose:**

To verify an IKEv2 device ignores the content of Version in IKE messages.

**References:**

- [RFC 4306] - Sections 3.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Packet #1)
  |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Judgment #1)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>Version bit is set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request whose Version bit is set to one.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.11.4: Response bit is set

**Purpose:**

To verify an IKEv2 device ignores an IKE request message whose Response bit is set.

**References:**

- [RFC 4306] - Sections 2.21

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
 (SGW)               (SGW)
   |                   |
   |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Packet #1)
   |-------X           | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Judgment #1)
   |                   |
   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>Response bit is set to one. |

*Part A (BASIC)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request whose Response bit is set to one.
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT never responds with an IKE_SA_INIT response to an IKE_SA_INIT request from the TN1.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.1.11.5: Unrecognized Notify Message Type

**Purpose:**

To verify an IKEv2 device ignores the unrecognized Notify Message Type in IKE messages.

**References:**

- [RFC 4306] - Sections 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                 NUT                 TN1                 TH2
(Host)              (SGW)               (SGW)               (Host)
  |                   |                   |                   |
  |                   |<------------------|                   | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   |                   |                   | (Packet #1)
  |                   |------------------>|                   | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   |                   |                   | (Judgment #1)
  |                   |                   |                   |
  |                   |<------------------|                   | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                   |                   |                   |                         SAi2, TSi, TSr, N})
  |                   |                   |                   | (Packet #2)
  |                   |------------------>|                   | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                   |                   |                   |                          SAr2, TSi, TSr})
  |                   |                   |                   | (Judgment #2)
  |                   |                   |                   |
  |<------------------+===================+-------------------| IPsec {Echo Request}
  |                   |                   |                   | (Packet#3) (Judgment #3)
  |-------------------+===================+------------------>| IPsec {Echo Reply}
  |                   |                   |                   | (Packet #4) (Judgment #4)
  |                   |                   |                   |
  V                   V                   V                   V

N: Notify Payload with unrecognized Notify Message Type
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

Packet #2: IKE_AUTH request

| | |
|---|---|
| IPv6 Header | All fields are same as Common Packet #5 |
| UDP Header | All fields are same as Common Packet #5 |
| IKEv2 Header | All fields are same as Common Packet #5 |
| E Payload | All fields are same as Common Packet #5 |

| | | |
|---|---|---|
| IDi Payload | All fields are same as Common Packet #5 | |
| AUTH Payload | All fields are same as Common Packet #5 | |
| SA Payload | All fields are same as Common Packet #5 | |
| TSi Payload | All fields are same as Common Packet #5 | |
| TSr Paylaod | Next Payload | 41 (Notify) |
| | Other fields are same as Common Packet #5 | |
| N Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 8 |
| | Procotol ID | 0 |
| | SPI Size | 0 |
| | Notify Message Type | See each part description. |

*Part A: Unrecognized Notify Message Type of error 16383 (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a Notify payload of unrecognized Notify Message Type value (16383) to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.

*Part B: Unrecognized Notify Message Type of status 65535 (BASIC)*

9. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request with a Notify payload of unrecognized Notify Message Type value (65535) to the NUT.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

*Part B*

**Step 10: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 12: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 14: Judgment #3**
The NUT forwards an Echo Request.

**Step 16: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using ENCR_3DES and AUTH_HMAC_SHA1_96.

**Possible Problems:**

- None.

# Group 2. The CREATE_CHILD_SA Exchange

## Group 2.1. Header and Payload Formats

### Test IKEv2.SGW.R.1.2.1.1: Receipt of CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device transmits a CREATE_CHILD_SA response using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.1.2,1.2 and 3.3.2
- [RFC 4307] - Sections 3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Packet #1)
  |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Judgment #1)
  |                 |
  |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Packet #2)
  |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  |<----------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                 | (Packet #3)
  |---------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                 | (Judgment #3)
  |                 |
  V                 V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #15 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
6. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
12. Observe the messages transmitted on Link A.

*Part C: SA Payload Format (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
18. Observe the messages transmitted on Link A.

*Part D: Nonce Payload Format (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
24. Observe the messages transmitted on Link A.

*Part E: TSi Payload Format (BASIC)*

25. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
26. Observe the messages transmitted on Link A.
27. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH request to the NUT.
28. Observe the messages transmitted on Link A.
29. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
30. Observe the messages transmitted on Link A.

*Part F: TSr Payload Format (BASIC)*

31. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
32. Observe the messages transmitted on Link A.
33. After a reception of IKE_SA_INIT response from the NUT, TN1 transmits IKE_AUTH

request to the NUT.
34. Observe the messages transmitted on Link A.
35. After reception of IKE_AUTH response from the NUT, TN1 transmits CREATE_CHILD_SA request to the NUT to rekey CHILD_SAs.
36. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 160 Header format**

- An IKE_SA Initiator’s SPI field set to same as the IKE_SA_INIT request’s IKE_SA Initiator’s SPI field value.
- An IKE_SA Responder’s SPI field set to same as the IKE_SA_INIT response’s IKE_SA Responder’s SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to CREATE_CHILD_SA (36).
- A Flags field set to $(00000100)_2 = (4)_{10}$.
- A Message ID field set to the same value as corresponding IKEv2 request message’s Message ID.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 161 Encrypted payload**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**

```
                              1                   2                   3
          0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
         ! Next     44    !0!      0      ! Length          40          !              |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---          |
         !       0        !        0      ! Length          36          !  |           |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         ! Number     1   ! Prot ID   3   ! SPI Size  4   ! Trans Cnt  3 !  |           |
         +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
         ! SPI value                                                    !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       | !       3        !        0      ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |SA Payload
       | ! Type  1  (EN) !        0      ! Transform ID     3     (3DES) !  | Proposal  |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       | !       3        !        0      ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       | ! Type  3  (IN) !        0      ! Transform ID     2     (SHA1) !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       | !       0        !        0      ! Length           8          !  |           |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |           |
       | ! Type  5  (ESN)!        0      ! Transform ID     0      (No)  !  |           |
     --- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 162 SA Payload contents**

The NUT transmits a CREATE_CHILD_SA response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 163 SA Payload format**

- A Next Payload field set to Nr Payload (40).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

A Proposals field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 164 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero (last).
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity's SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 165 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including

Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.

- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted Nonce Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                            Nonce Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 166 Nonce Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Nonce Data field set to random data generated by the transmitting entity. The size of the Nonce must between 16 and 256 octets.

*Part E*

**Step 26: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 28: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 30: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 167 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 168 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix Y.
- A Ending Address field set to greater thatn or equal to Prefix Y.

*Part G*

**Step 32: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 34: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 36: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including properly formatted TSr Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 169 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to the number of actual traffic selectors.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 170 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.

- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- An Ending Address field set to less than or equal to Prefix B.

**Possible Problems:**

- CREATE_CHILD_SA response has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
[N(IPCOMP_SUPPORTED)],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, Nr, [KEr], TSi, TSr,
[N(ADDITIONAL_TS_POSSIBLE)]
```

- Each of transforms can be located in the any order.

## Group 2.2. Use of Retransmission Timers

### Test IKEv2.SGW.R.1.2.2.1: Receipt of CREATE_CHILD_SA requests

**Purpose:**

To verify an IKEv2 device retransmits CREATE_CHILD_SA request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 2.1, 2.2 and 2.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #1)
  |               |
  |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               | (Packet #2)
  |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               | (Judgment #2)
  |               |
  |<--------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |               | (Packet #3)
  |-------------->| CREATE_CHILD_SA Rsponce Catl (HDR, SK {SA, Nr, TSi, TSr})
  |               | (Judgment #3)
  |               |
  |               * wait until retrans timer expires
  |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |               | (Judgment #4)
  |               |
  |<--------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |               | (Packet #4)
  |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |               | (Judgment #5)
  |               |
  V               V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #15 |
| Packet #4 | See Common Packet #15<br>(same Message ID as Pcket #3) |

*Part A: (BASIC)*

1. TN1 transmits IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits CREATE_CHILD_SA request.
6. Observe the messages transmitted on Link A.
7. Observe the messages transmitted on Link A.
8. TN1 transmits the same CREATE_CHILD_SA request packet as Step 5.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 7: Judgment #4**
The NUT never retransmits a CREATE_CHILD_SA response which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Step 9: Judgment #5**
The NUT retransmits a CREATE_CHILD_SA response which has the same Message ID value as the previous CREATE_CHILD_SA request's Message ID value in IKE Header.

**Possible Problems:**

- none

# Group 2.3. State Synchronization and Connection Timeouts

## Test IKEv2.SGW.R.1.2.3.1: Receiving Delete Payload for Multiple CHILD_SA

**Purpose:**

To verify an IKEv2 device transmits a Delete Payload, when CHILD_SAs are deleted.

**References:**

- [RFC 4306] - Sections 2.4 and 3.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Judgment #1)
  |                 |
  |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Packet #2)
  |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni, TSi, TSr})
  |                 | (Packet #3)
  |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                 | (Judgment #3)
  |                 |
  |<--------------| INFORMATIONAL request (HDR, SK {D})
  |                 | (Packet #4)
  |-------------->| INFORMATIONAL request (HDR, SK {D})
  |                 | (Judgment #4)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Same as the Common Packet #5 | |
| AUTH Payload | Same as the Common Packet #5 | |
| N Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 6 (TCP) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #9 | |
| UDP Header | Same as the Common Packet #9 | |
| IKEv2 Header | Same as the Common Packet #9 | |
| E Payload | Same as the Common Packet #9 | |
| N Payload | Same as the Common Packet #9 | |
| SA Payload | Same as the Common Packet #9 | |
| Ni, Nr Payload | Same as the Common Packet #9 | |
| TSi Payload | Other fields are same as the Common Packet #9 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #9 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix Y:0000:0000:0000:0000 |
| | | Ending Address | Prefix Y:ffff:ffff:ffff:ffff |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 58 (ICMPv6) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | Prefix B:0000:0000:0000:0000 |
| | | Ending Address | Prefix B:ffff:ffff:ffff:ffff |

- Packet #4: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | | Same as the Common Packet #17 |
| UDP Header | | Same as the Common Packet #17 |
| IKEv2 Header | | Same as the Common Packet #17 |
| E Payload | | Other fields are same as the Common Packet #17 |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 2 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |
| | | SPI negotiated by CREATE_CHILD_SA exchange |

*Part A: (ADVANCED)*

1. TN starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to establish a new CHILD_SA to the NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an INFORMATIONAL request with a Delete payload including the first negotiated CHILD_SA’s inbound SPI and the second negotiated CHILD_SA’s inbound SPI.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 8: Judgment #4**
The NUT transmits an INFORMATIONAL response with delete payload for SPIs which are negotiated by Initial Exchange and CREATE_CHILD_SA exchange.

**Possible Problems:**

- INFORMATIONAL response from NUT may not contain Delete Payload by implementation policy. This behavior is defined at section 1.4 in RFC 4306 as an exception.

## Group 2.4. Cryptographic Algorithm Negotiation

### Test IKEv2.SGW.R.1.2.4.1: Sending NO_PROPOSAL_CHOSEN

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 2.7 and 3.10.1
- [RFC 4718] - Sections 2.1 and 2.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  |<---------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                | (Packet #3)
  |-------X        | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                | (Judgment #3)
  |                |   or
  |--------------->| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
  |                | (Judgment #3)
  |                |
  V                V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Other fields are same as the Common Packet #15 | |
| | SA Proposals | See below |
| Ni, Nr Payload | Same as the Common Packet #15 | |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 36 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 3 |
| | | SPI | | any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 12 (AES_CBC) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 5 (AES_XCBC_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 1 (ESN) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to rekey the established CHILD_SAs to the NUT. The CREATE_CHILD_SA request includes a SA payload with a proposal unaccepted by the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT does not transmit a CREATE_CHILD_SA response or transmits a CREATE_CHILD_SA response including a Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None.

## Group 2.5. Rekeying CHILD_SA Using a CREATE_CHILD_SA exchange

### Test IKEv2.SGW.R.1.2.5.1: Close the replaced CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the CREATE_CHILD_SA Exchanges to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1                TH2
(Host)             (SGW)              (SGW)              (Host)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  |                  | (Packet #1)
  |                  |----------------->|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                  |                  | (Judgment #1)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                  |                  | (Packet #2)
  |                  |----------------->|                  | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                  |                  | (Judgment #2)
  |                  |                  |                  |
  |<-----------------+==================+------------------| IPsec {Echo Request}
  |                  |                  |                  | (Packet #3) (Judgment #3)
  |------------------+==================+----------------->| IPsec {Echo Reply}
  |                  |                  |                  | (Packet #4) (Judgment #4)
  |                  |                  |                  |
  |                  |<-----------------|                  | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                  |                  |                  | (Packet #5)
  |                  |----------------->|                  | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                  |                  |                  | (Judgment #5)
  |                  |                  |                  |
  |                  |<-----------------|                  | INFORMATIONAL request (HDR, SK {D})
  |                  |                  |                  | (Packet #6)
  |                  |----------------->|                  | INFORMATIONAL response (HDR, SK {D})
  |                  |                  |                  | (Judgment #6)
  |                  |                  |                  |
  V                  V                  V                  V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See below |

- Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request including a Delete payload with the old CHILD_SA's SPI value to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response including a Delete payload with the old CHILD_SA's SPI value to the TN1.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.1.2.5.2: Use of the new CHILD_SA

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of CHILD_SAs.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1                TH2
(Host)             (SGW)              (SGW)              (Host)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  |                  | (Packet #1)
  |                  |----------------->|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                  |                  | (Judgment #1)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                  |                  | (Packet #2)
  |                  |----------------->|                  | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                  |                  | (Judgment #2)
  |                  |                  |                  |
  |<-----------------+==================+------------------| IPsec {Echo Request}
  |                  |                  |                  | (Packet #3) (Judgment #3)
  |------------------+==================+----------------->| IPsec {Echo Reply}
  |                  |                  |                  | (Packet #4) (Judgment #4)
  |                  |                  |                  |
  |                  |<-----------------|                  | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |                  |                  |                  | (Packet #5)
  |                  |----------------->|                  | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |                  |                  |                  | (Judgment #5)
  |                  |                  |                  |
  |                  |<-----------------|                  | INFORMATIONAL request (HDR, SK {D})
  |                  |                  |                  | (Packet #6)
  |                  |------------------|                  | INFORMATIONAL response (HDR, SK {D})
  |                  |                  |                  | (Judgment #6)
  |                  |                  |                  |
  |<-----------------+==================+------------------| IPsec {Echo Request}  (new CHILD_SA)
  |                  |                  |                  | (Packet #7) (Judgment #7)
  |------------------+==================+----------------->| IPsec {Echo Reply}    (new CHILD_SA)
  |                  |                  |                  | (Packet #8) (Judgment #8)
  |                  |                  |                  |
  V                  V                  V                  V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See below |
| Packet #7 | See Common Packet #21 (encrypted by the new CHILD_SA) |
| Packet #8 | See Common Packet #25 |

Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| UDP Header | Source Port | 500 |
| | Destination Port | 500 |
| IKEv2 Header | IKE_SA Initiator's SPI | any |
| | IKE_SA Responder's SPI | any |
| | Next Payload | 46 (E) |
| | Major Version | 2 |
| | Minor Version | 0 |
| | Exchange Type | 37 (INFORMATIONAL) |
| | X (bits 0-2 of Flags) | 0 |
| | I (bit 3 of Flags) | any |
| | V (bit 4 of Flags) | 0 |
| | R (bit 5 of Flags) | 0 |
| | X (bits 6-7 Flags) | 0 |
| | Message ID | 0 |
| | Length | any |
| E Payload | Next Payload | 42 (D) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | any |
| | Initialization Vector | The same value as block length of the underlying encryption algorithm |
| | Encrypted IKE Payloads | Subsequent payloads encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Integrity Checksum Data | The Cryptographic checksum of the entire message |
| D Payload | Next Payload | 0 |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Protocol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index | NUT's inbound CHILD_SA SPI value to be deleted |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request using the first negotiated algorithms to the NUT.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.

8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA’s SPI value in the SPI field to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request with a Delete payload to the NUT.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1. TH1. TN1 forwards an Echo Request using the second negotiated algorithms to the NUT.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotiated algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the NUT’s inbound SPI value to be deleted as SPI value.

**Step 14: Judgment #7**
The NUT forwards an Echo Request.

**Step 16: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.5.3: Receiving Multiple Transform

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT              TN1
  (SGW)            (SGW)
    |                |
    |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                | (Packet #2)
    |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                | (Judgment #2)
    |                |
    |<---------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
    |                | (Packet #3)
    |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
    |                | (Judgment #3)
    V                V

 N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

From part A to part C, TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the transforms as follows:

| | **CREATE_CHILD_SA exchanges Algorithms** | | |
|---|---|---|---|
| | **Encryption** | **Integrity** | **ESN** |
| **Part A** | **ENCR_3DES**<br>**ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | ENCR_3DES | **AUTH_HMAC_SHA1_96**<br>**AUTH_AES_XCBC_96** | No ESN |

| | | | |
|---|---|---|---|
| **Part C** | ENCR_3DES | AUTH_HMAC_SHA1_96 | **No ESN**<br>**ESN** |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| IDi Payload | Same as the Common Packet #15 | |
| AUTH Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Other fields are same as the Common Packet #15 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.

6. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.5.4: Receiving Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transforms to rekey CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
   NUT                TN1
  (SGW)              (SGW)
    |                  |
    |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                  | (Packet #1)
    |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                  | (Judgment #1)
    |                  |
    |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
    |                  | (Packet #2)
    |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
    |                  | (Judgment #2)
    |                  |
    |<-----------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
    |                  | (Packet #3)
    |----------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
    |                  | (Judgment #3)
    V                  V

 N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the two proposals as follows:

| | **CREATE_CHILD_SA exchanges Algorithms** | | | | |
|---|---|---|---|---|---|
| | **Proposal** | **Protocol ID** | **Encryption** | **Integrity** | **ESN** |
| **Part A** | Proposal #1 | ESP | **ENCR_AES_CBC** | AUTH_HMAC_SHA1_96 | No ESN |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part B** | Proposal #1 | ESP | ENCR_3DES | **AUTH_AES_XCBC_96** | No ESN |

| | | | | | |
|---|---|---|---|---|---|
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |
| **Part C** | Proposal #1 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | **ESN** |
| | Proposal #2 | ESP | ENCR_3DES | AUTH_HMAC_SHA1_96 | No ESN |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| IDi Payload | Same as the Common Packet #15 | |
| AUTH Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Other fields are same as the Common Packet #15 | |
| | SA Proposals | See below |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 40 |
| | | Proposal # | | 2 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 4 |
| | | SPI | | Any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 0 (No ESN) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Integrity Algorithms (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Extended Sequecnce Numbers (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.5.5: Perfect Forward Secrecy

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA exchange when Perfect Forward Secrecy enables.

**References:**

- [RFC 4306] - Sections 2.12

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT               TN1               TH2
(Host)             (SGW)             (SGW)             (Host)
  |                  |                 |                 |
  |                  |<--------------|                 | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                 |                 | (Packet #1)
  |                  |-------------->|                 | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                 |                 | (Judgment #1)
  |                  |                 |                 |
  |                  |<--------------|                 | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                 |                 | (Packet #2)
  |                  |-------------->|                 | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                 |                 | (Judgment #2)
  |                  |                 |                 |
  |<-------------+===============+--------------| IPsec {Echo Request}
  |                  |                 |                 | (Packet #3) (Judgment #3)
  |--------------+===============+------------->| IPsec {Echo Reply}
  |                  |                 |                 | (Packet #4) (Judgment #4)
  |                  |                 |                 |
  |                  |<--------------|                 | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, KEi,
  |                  |                 |                 |                                  TSi, TSr})
  |                  |                 |                 | (Packet #5)
  |                  |-------------->|                 | CREATE_CHILD_SA response (HDR, SK {SA, Nr, KEr,
  |                  |                 |                 |                                   TSi, TSr})X
  |                  |                 |                 | (Judgment #5)
  |                  |                 |                 |
  |                  |<--------------|                 | INFORMATIONAL request (HDR, SK {D})
  |                  |                 |                 | (Packet #6)
  |                  |---------------|                 | INFORMATIONAL response (HDR, SK {D})
  |                  |                 |                 | (Judgment #6)
  |                  |                 |                 |
  |<-------------+===============+--------------| IPsec {Echo Request}  (new CHILD_SA)
  |                  |                 |                 | (Packet #7) (Judgment #7)
  |--------------+===============+------------->| IPsec {Echo Reply}    (new CHILD_SA)
  |                  |                 |                 | (Packet #8) (Judgment #8)
  |                  |                 |                 |
  V                  V                 V                 V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See Common Packet #21<br>(encrypted by the new CHILD_SA) |
| Packet #8 | See Common Packet #25 |

Packet #5: CREATE_CHILD_SA response

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Same as the Common Packet #15 | |
| Ni Payload | Next Payload | 34 (KE) |
| KEi Payload | Next Payload | 44 (TSi) |
| | Critical | 0 |

| | | |
|---|---|---|
| | Reserved | 0 |
| | Payload Length | 136 |
| | DH Group # | 2 |
| | Reserved | 0 |
| | Key Exchange Data | any |
| TSi Payload | Same as the Common Packet #15 | |
| TSr Payload | Same as the Common Packet #15 | |

Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request using the first negotiated algorithms to the NUT.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request with a Delete payload to the NUT.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request using the second negotiated algorithms to the NUT.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotiated algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response with a Delete payload. The Delete payload includes 3 (ESP) as Protocol ID, 4 as SPI Size and the NUT's inbound SPI value to be deleted as SPI value.

**Step 14: Judgment #7**
The NUT forwards an Echo Request.

**Step 16: Judgment #8**
The NUT forwards an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.5.6: Use of the old CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles new CHILD_SA and old CHILD_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |<--------------|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Packet #1)
  |               |-------------->|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Judgment #1)
  |               |               |               |
  |               |<--------------|               | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |-------------->|               | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  |               |<--------------|               | CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
  |               |               |               | (Packet #5)
  |               |-------------->|               | CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
  |               |               |               | (Judgment #5)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}  (old CHILD_SA)
  |               |               |               | (Packet #6) (Judgment #6)
  |---------------+===============+-------------->| IPsec {Echo Reply}    (old CHILD_SA or new CHILD_SA)
  |               |               |               | (Packet #7) (Judgment #7)
  |               |               |               |
  V               V               V               V

N: REKEY_SA
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #3 |
| Packet #3 | See Common Packet #21 |

| | |
|---|---|
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #15 |
| Packet #6 | See Common Packet #21<br>(encrypted by the old CHILD_SA) |
| Packet #7 | See Common Packet #25 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request using the first negotiated algorithms to the NUT.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
10. Observe the messages transmitted on Link A.
11. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request using the first negotiated algorithms again.
12. Observe the messages transmitted on Link B.
13. TH1 transmits an Echo Reply to TH2.
14. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotiated algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT forwards an Echo Request.

**Step 14: Judgment #7**

The NUT forwards an Echo Reply with IPsec ESP. The NUT can use both the first CHILD_SA and the new CHILD_SA.

**Possible Problems:**

- none

# Group 2.6. Rekeying IKE_SAs Using a CREATE_CHILD_SA exchange

## Test IKEv2.SGW.R.1.2.6.1: Sending CREATE_CHILD_SA response

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8 and 2.18

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1                TH2
(Host)             (SGW)              (SGW)              (Host)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  |                  | (Packet #1)
  |                  |----------------->|                  | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                  |                  | (Judgment #1)
  |                  |                  |                  |
  |                  |<-----------------|                  | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                  |                  |                  | (Packet #2)
  |                  |----------------->|                  | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                  |                  |                  | (Judgment #2)
  |                  |                  |                  |
  |<-----------------+==================+------------------| IPsec {Echo Request}
  |                  |                  |                  | (Packet #3) (Judgment #3)
  |------------------+==================+----------------->| IPsec {Echo Reply}
  |                  |                  |                  | (Packet #4) (Judgment #4)
  |                  |                  |                  |
  |                  |<-----------------|                  | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                  |                  |                  | (Packet #5)
  |                  |----------------->|                  | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                  |                  |                  | (Judgment #5)
  |                  |                  |                  |
  V                  V                  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #11 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a SA payload. The proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA Initiator's SPI value.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including"ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload Response includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA Responder's SPI value in the SPI field.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.2: Receipt of cryptographically valid message on the old SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |<--------------|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Packet #1)
  |               |-------------->|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Judgment #1)
  |               |               |               |
  |               |<--------------|               | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |-------------->|               | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  |               |<--------------|               | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |               |               |               | (Packet #5)
  |               |-------------->|               | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |               |               |               | (Judgment #5)
  |               |               |               |
  |               |<--------------|               | INFORMATION Request (HDR, SK {})
  |               |               |               | (Packet #6)
  |               |-------------->|               | INFORMATIONAL response (HDR, SK {})
  |               |               |               | (Judgment #6)
  |               |               |               |
  V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

| | |
|---|---|
| Packet #5 | See Common Packet #11 |
| Packet #6 | See Common Packet #17<br>(encrypted by the old IKE_SA) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA Initiator's SPI value.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request with no payloads protected by the old IKE_SA.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA Responder's SPI value in the SPI field.

**Step 12: Judgment #6**
The NUT responds with an INFORMATIONAL response with no payloads protected by the old IKE_SA.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.3: Receipt of cryptographically valid message on the new SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |<---------------|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Packet #1)
  |                |--------------->|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Judgment #1)
  |                |                |                |
  |                |<---------------|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |--------------->|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}
  |                |                |                | (Packet #3) (Judgment #3)
  |----------------+================+--------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                |                |                | (Packet #5)
  |                |--------------->|                | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                |                |                | (Judgment #5)
  |                |                |                |
  |                |<---------------|                | INFORMATION Request (HDR, SK {})
  |                |                |                | (Packet #6)
  |                |--------------->|                | INFORMATIONAL response (HDR, SK {})
  |                |                |                | (Judgment #6)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

| | |
|---|---|
| Packet #5 | See Common Packet #11 |
| Packet #6 | See Common Packet #17 (encrypted by the new IKE_SA) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA Initiator's SPI value.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA Responder's SPI value in the SPI field.

**Step 12: Judgment #6**
The NUT responds with an INFORMATIONAL response with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.4: Close the replaced IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.8 and 5.11

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1               NUT               TN1               TH2
(Host)            (SGW)             (SGW)             (Host)
  |                 |                 |                 |
  |                 |<----------------|                 | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 |                 |                 | (Packet #1)
  |                 |---------------->|                 | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 |                 |                 | (Judgment #1)
  |                 |                 |                 |
  |                 |<----------------|                 | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 |                 |                 | (Packet #2)
  |                 |---------------->|                 | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 |                 |                 | (Judgment #2)
  |                 |                 |                 |
  |<----------------+=================+-----------------| IPsec {Echo Request}
  |                 |                 |                 | (Packet #3) (Judgment #3)
  |-----------------+=================+---------------->| IPsec {Echo Reply}
  |                 |                 |                 | (Packet #4) (Judgment #4)
  |                 |                 |                 |
  |                 |<----------------|                 | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                 |                 |                 | (Packet #5)
  |                 |---------------->|                 | CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                 |                 |                 | (Judgment #5)
  |                 |                 |                 |
  |                 |<----------------|                 | INFORMATION Request (HDR, SK {D})
  |                 |                 |                 | (Packet #6)
  |                 |---------------->|                 | INFORMATIONAL response (HDR, SK {})
  |                 |                 |                 | (Judgment #6)
  |                 |                 |                 |
  |<----------------+=================+-----------------| IPsec {Echo Request}
  |                 |                 |                 | (Packet #7) (Judgment #7)
  |-----------------+=================+---------------->| IPsec {Echo Reply}
  |                 |                 |                 | (Packet #8) (Judgment #8)
  |                 |                 |                 |
  V                 V                 V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |

| | |
|---|---|
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #11 |
| Packet #6 | See below |
| Packet #7 | See Common Packet #21 |
| Packet #8 | See Common Packet #25 |

- Packet #6: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index(es) (SPI) | empty |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request to rekey IKE_SA. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA Initiator’s SPI value.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request with a Delete payload which has 1 (IKE_SA) in the Protocol ID field, zero in the SPI Size field and zero in the # of SPIs field.
12. Observe the messages transmitted on Link A.
13. TH2 transmits an Echo Request to TH1. TN1 forwards an Echo Request with IPsec ESP with corresponding algorithms inherited from the replaced IKE_SA.
14. Observe the messages transmitted on Link B.
15. TH1 transmits an Echo Reply to TH2.
16. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA Responder's SPI value in the SPI field.

**Step 12: Judgment #6**
The NUT responds with an INFORMATIONAL response with no payloads.

**Step 14: Judgment #3**
The NUT forwards an Echo Request.

**Step 16: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms inherited from the replaced IKE_SA.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.5: Receiving Multiple Transform

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple transform to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Judgment #1)
   |                |
   |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                | (Packet #2)
   |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH SAr2, TSi, TSr})
   |                | (Judgment #2)
   |                |
   |<---------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
   |                | (Packet #3)
   |--------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr })
   |                | (Judgment #3)
   V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

From part A to part D, TN1 transmits an IKE_SA_INIT request including a SA payload which contains the transforms as follows:

| | IKE_SA_INIT exchanges Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | **ENCR_AES_CBC**<br>**ENCR_3DES** | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part B** | ENCR_3DES | **PRF_AES128_CBC**<br>**PRF_HMAC_SHA1** | AUTH_HMAC_SHA1_96 | Group 2 |
| **Part C** | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96**<br>**AUTH_HMAC_SHA1_96** | Group 2 |

| Part D | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 14 or Group 24, Group 2 |
|---|---|---|---|---|

- Packet #3 CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #11 | |
| UDP Header | Same as the Common Packet #11 | |
| IKEv2 Header | Same as the Common Packet #11 | |
| SA Payload | Other fields are same as the common packet #11 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Same as the Common Packet #11 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | According to above configuration |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo Random Function (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: MultipleIntegrity Algorithm (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Group (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.6: Receiving Multiple Proposal

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with multiple proposal to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.7, 2.8 and 3.3

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT             TN1
 (SGW)           (SGW)
   |               |
   |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |               | (Packet #1)
   |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |               | (Judgment #1)
   |               |
   |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |               | (Packet #2)
   |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |               | (Judgment #2)
   |               |
   |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
   |               | (Packet #3)
   |-------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
   |               | (Judgment #3)
   V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

TN1 transmits a CREATE_CHILD_SA request including a SA payload which contains the two proposals as follows:

| | IKE_SA_INIT exchanges Algorithms | | | | | |
|---|---|---|---|---|---|---|
| | Proposals | Protocol ID | Encryption | PRF | Integrity | D-H Group |
| Part A | Proposal #1 | IKE | ENCR_AES_CBC | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part B | Proposal #1 | IKE | ENCR_3DES | PRF_AES128_CBC | AUTH_HMAC_SHA1_96 | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Part C | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | **AUTH_AES_XCBC_96** | Group 2 |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |
| Part D | Proposal #1 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | **Group 14 or Group 24** |
| | Proposal #2 | IKE | ENCR_3DES | PRF_HMAC_SHA1 | AUTH_HMAC_SHA1_96 | Group 2 |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #11 | |
| UDP Header | Same as the Common Packet #11 | |
| IKEv2 Header | Same as the Common Packet #11 | |
| SA Payload | Other fields are same as the common packet #11 | |
| | SA Proposals | See SA Table below |
| Ni, Nr Payload | Same as the Common Packet #11 | |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 2 (more) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 1 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | According to above configuration |
| Proposal #2 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 44 |
| | | Proposal # | | 2 |
| | | Protocol ID | | 1 (IKE) |
| | | SPI Size | | 0 |
| | | # of Transforms | | 5 |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 3 (3DES) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |

| | | | | |
|---|---|---|---|---|
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (HMAC_SHA1_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 4 (D-H) |
| | | | Reserved | 0 |
| | | | Transform ID | 2 (1024 MODP Group) |

*Part A: Multiple Encryption Algorithms (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Multiple Pseudo Random Function (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
12. Observe the messages transmitted on Link A.

*Part C: Multiple Integrity Algorithms (BASIC)*

13. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
14. Observe the messages transmitted on Link A.
15. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
16. Observe the messages transmitted on Link A.
17. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.
18. Observe the messages transmitted on Link A.

*Part D: Multiple D-H Group (BASIC)*

19. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
20. Observe the messages transmitted on Link A.
21. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT.

24. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part B*

**Step 8: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 10: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 12: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part C*

**Step 14: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 16: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 18: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

*Part D*

**Step 20: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 22: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 24: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- none

## Test IKEv2.SGW.R.1.2.6.7: Changing RPFs when rekeying the IKE_SA

**Purpose:**

To verify an IKEv2 device properly handles CREATE_CHILD_SA to rekey IKE_SA.

**References:**

- [RFC 4306] - Sections 2.8
- [RFC 4718] - Sections 5.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
  Configure the devices according to the Common Configuration except for *Italic* parameters.

| | IKE_SA Rekeying Algorithms | | | |
|---|---|---|---|---|
| | **Encryption** | **PRF** | **Integrity** | **D-H Group** |
| **Part A** | ENCR_3DES | ***PRF_AES128_XCBC*** | AUTH_HMAC_SHA1_96 | Group 14 |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Packet #1)
  |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Judgment #1)
  |                 |
  |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Packet #2)
  |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  |<----------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                 | (Packet #3)
  |---------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr})
  |                 | (Judgment #3)
  |                 |
  |<----------------| INFORMATION Request (HDR, SK {})
  |                 | (Packet #4)
  |---------------->| INFORMATIONAL response (HDR, SK {})
  |                 | (Judgment #4)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

| | |
|---|---|
| Packet #3 | See Common Packet #11 |
| Packet #4 | See Common Packet #17<br>(encrypted by the new IKE_SA) |

Packet #3: CREATE_CHILD_SA request

Packet #3 is same as Common Packet #11 except SA Transform proposed in each test.

Part A:

SA Transform of Tranform Type D-H is replaced by the following SA Transfrom.

| | | |
|---|---|---|
| SA Transform | Next Payload | 0 (last) |
| | Reserved | 0 |
| | Transform Length | 8 |
| | Transform Type | 2 (PRF) |
| | Reserved | 0 |
| | Transform ID | 4 (PRF_AES128_XCBC) |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA Initiator's SPI value.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an INFORMATIONAL request with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.
8. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**

The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 14" as proposed algorithms. And the proposal in the SA payload includes 1 (IKE) in the Protocol ID field, 8 in the SPI size field and rekeyed IKE_SA Responder's SPI value in the SPI field.

**Step 8: Judgment #4**

The NUT responds with an INFORMATIONAL response with no payloads protected by the new IKE_SA and the Message ID field in the IKE header is zero.

**Possible Problems:**

- none

### Test IKEv2.SGW.R.1.2.6.8: D-H transform NONE when rekeying the IKE_SA

This test case was deleted at revision 1.1.0.

## Test IKEv2.SGW.R.1.2.6.9: Rekeying Failure

**Purpose:**

To verify an IKEv2 device properly handles a CREATE_CHILD_SA request with an unacceptable SA payload.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT             TN1
(SGW)           (SGW)
  |               |
  |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               | (Packet #1)
  |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               | (Judgment #1)
  |               |
  |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               | (Packet #2)
  |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               | (Judgment #2)
  |               |
  |<--------------| CREATE_CHILD_SA request (HDR, SK {SA, Ni, KE})
  |               | (Packet #3)
  |-------------->| CREATE_CHILD_SA response (HDR, SK {N(NO_PROPOSAL_CHOSEN)})
  |               | (Judgment #3)
  |               |
  V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See below |

- Packet #3: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #15 | |
| UDP Header | Same as the Common Packet #15 | |
| IKEv2 Header | Same as the Common Packet #15 | |
| E Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| N Payload | Same as the Common Packet #15 | |
| SA Payload | Other fields are same as the Common Packet #15 | |
| | SA Proposals | See below |

| | |
|---|---|
| Ni, Nr Payload | Same as the Common Packet #15 |
| TSi Payload | Same as the Common Packet #15 |
| TSr Payload | Same as the Common Packet #15 |

| | | | | |
|---|---|---|---|---|
| Proposal #1 | SA Proposal | Next Payload | | 0 (last) |
| | | Reserved | | 0 |
| | | Proposal Length | | 36 |
| | | Proposal # | | 1 |
| | | Proposal ID | | 3 (ESP) |
| | | SPI Size | | 4 |
| | | # of Transforms | | 3 |
| | | SPI | | any |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 1 (ENCR) |
| | | | Reserved | 0 |
| | | | Transform ID | 12 (AES_CBC) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 2 (PRF) |
| | | | Reserved | 0 |
| | | | Transform ID | 4 (AES128_XCBC) |
| | | SA Transform | Next Payload | 3 (more) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 3 (INTEG) |
| | | | Reserved | 0 |
| | | | Transform ID | 5 (AES_XCBC_96) |
| | | SA Transform | Next Payload | 0 (last) |
| | | | Reserved | 0 |
| | | | Transform Length | 8 |
| | | | Transform Type | 5 (ESN) |
| | | | Reserved | 0 |
| | | | Transform ID | 1 (ESN) |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 trasmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request to rekey the established IKE_SA to the NUT. The CREATE_CHILD_SA request includes a SA payload with a proposal unaccepted by the NUT.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including a Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None.

# Group 2.7. Creating New CHILD_SA with the CREATE_CHILD_SA Exchange

## Test IKEv2.SGW.R.1.2.7.1: Receipt of cryptographically protected message on the new SA

**Purpose:**

To verify an IKEv2 device properly recognizes the lifetime of CHILD_SAs.

**References:**

- [RFC 4306] - Sections 2.8

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2              TH3
(Host)           (SGW)            (SGW)            (Host)           (Host)
  |                |                |                |                |
  |                |<---------------|                |                | IKE_SA_INIT request (HDR, SAi1,
  |                |                |                |                |                           KEi, Ni)
  |                |                |                |                | (Packet #1)
  |                |--------------->|                |                | IKE_SA_INIT response (HDR, SAr1,
  |                |                |                |                |                           KEr, Nr)
  |                |                |                |                | (Judgment #1)
  |                |                |                |                |
  |                |<---------------|                |                | IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                |                |                |                |                  SAi2, TSi, TSr})
  |                |                |                |                | (Packet #2)
  |                |--------------->|                |                | IKE_AUTH response (HDR, SK {IDr, AUTH,
  |                |                |                |                |                  SAr2, TSi, TSr})
  |                |                |                |                | (Judgment #2)
  |                |                |                |                |
  |<---------------+================+----------------|                | IPsec {Echo Request}
  |                |                |                |                | (Packet #3) (Judgment #3)
  |----------------+================+--------------->|                | IPsec {Echo Reply}
  |                |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |                |
  |        X-------+================+---------------------------------| IPsec {Echo Request}
  |                |                |                |                | (Packet #5) (Judgment #5)
  |----------------+========X       |                |                | IPsec {Echo Request}
  |                |                |                |                | (Packet #6) (Judgment #6)
  |                |                |                |                |
  |                |<---------------|                |                | CREATE_CHILD_SA request (HDR,
  |                |                |                |                |                SK{SA, Ni, TSi, TSr})
  |                |                |                |                | (Packet #7)
  |                |--------------->|                |                | CREATE_CHILD_SA response (HDR,
  |                |                |                |                |                SK{SA, Nr, TSi, TSr})
  |                |                |                |                | (Judgment #7)
  |                |                |                |                |
  |<---------------+================+----------------|                | IPsec {Echo Request}
  |                |                |                |                | (Packet #8) (Judgment #8)
  |----------------+================+--------------->|                | IPsec {Echo Reply}
  |                |                |                |                | (Packet #9) (Judgment #9)
  |                |                |                |                |
  |<---------------+================+---------------------------------| IPsec {Echo Request}
  |                |                |                |                | (Packet #10) (Judgment #10)
  |----------------+================+-------------------------------->| IPsec {Echo Reply}
  |                |                |                |                | (Packet #11) (Judgment #11)
  |                |                |                |                |
  V                V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |
| Packet #6 | See below |
| Packet #7 | See below |
| Packet #8 | See Common Packet #21 |
| Packet #9 | See Common Packet #25 |
| Packet #10 | See below |
| Packet #11 | See below |

- Packet #2: IKE_AUTH request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #5 | |
| UDP Header | Same as the Common Packet #5 | |
| IKEv2 Header | Same as the Common Packet #5 | |
| E Payload | Same as the Common Packet #5 | |
| IDi Payload | Same as the Common Packet #5 | |
| AUTH Payload | Same as the Common Packet #5 | |
| N Payload | Same as the Common Packet #5 | |
| SA Payload | Same as the Common Packet #5 | |
| TSi Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #5 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH2's Global Address on Link B |
| | | Ending Address | TH2's Global Address on Link B |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH1's Global Address on Link Y |
| | | Ending Address | TH1's Global Address on Link Y |

- Packet #5: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #6: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Distination Address | TH3's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #7: CREATE_CHILD_SA request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #4 | |
| UDP Header | Same as the Common Packet #4 | |
| IKEv2 Header | Same as the Common Packet #4 | |
| E Payload | Same as the Common Packet #4 | |
| IDi Payload | Same as the Common Packet #4 | |
| AUTH Payload | Same as the Common Packet #4 | |
| N Payload | Same as the Common Packet #4 | |
| SA Payload | Same as the Common Packet #4 | |
| TSi Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |
| TSr Payload | Other fields are same as the Common Packet #4 | |
| | Traffic Selectors | See below |

| | | | |
|---|---|---|---|
| TSi Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH3's Global Address on Link B |
| | | Ending Address | TH3's Global Address on Link B |

| | | | |
|---|---|---|---|
| TSr Payload | Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | | IP Protocol ID | 0 (any) |
| | | Selector Length | 40 |
| | | Start Port | 0 |
| | | End Port | 65535 |
| | | Starting Address | TH1's Global Address on Link Y |
| | | Ending Address | TH1's Global Address on Link Y |

- Packet #10: Echo Request

| | | |
|---|---|---|
| IPv6 Header | Source Address | TN1's Global Address on Link X |
| | Destination Address | NUT's Global Address on Link A |
| ESP | Security Parameter Index | CHILD_SA's SPI value used by this message |
| | Sequence Number | The value incremented the previous encrypted packet's Sequence Number by one. |
| | Payload Data | Subsequent data encrypted by underlying encryption algorithm |
| | Padding | Any value which to be a multiple of the encryption block size |
| | Pad Length | The length of the Padding field |
| | Next Header | 41 (IPv6) |
| | Integrity Check Value | The checksum must be valid by calculation according to the manner described in RFC. |
| IPv6 Header | Source Address | TH3's Global Address |
| | Destination Address | TH1's Global Address |
| ICMPv6 Header | Type | 128 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

- Packet #11: Echo Reply

| | | |
|---|---|---|
| IPv6 Header | Source Address | TH1's Global Address |
| | Distination Address | TH3's Global Address |
| ICMPv6 Header | Type | 129 |
| | Code | 0 |
| | Identifier | any |
| | Sequence Number | any |
| | Payload Data | 0x0000000000000000 |

*Part A: (ADVANCED)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link B.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link B.
5. TH2 transmits an Echo Request packet to TH1.
6. Observe the messages transmitted on Link A.
7. TH1 transmits an Echo Reply packet to TH2.
8. Observe the messages transmitted on Link B.
9. TH3 transmits an Echo Request packet to TH1.
10. Observe the messages transmitted on Link A.
11. TH1 transmits an Echo Request packet to TH3.
12. Observe the messages transmitted on Link B.
13. TN1 starts to negotiate new CHILD_SA with the NUT by sending CREATE_CHILD_SA request.
14. Observe the messages transmitted on Link B.
15. TH2 transmits an Echo Request packet to TH1.
16. Observe the messages transmitted on Link A.
17. TH1 transmits an Echo Reply packet to TH2.
18. Observe the messages transmitted on Link B.
19. TH3 transmits an Echo Request packet to TH1.
20. Observe the messages transmitted on Link A.
21. TH1 transmits an Echo Reply packet to TH3.
22. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using the first negotiated algorithms.

**Step 10: Judgment #5**
The NUT never forwards an Echo Request.

**Step 12: Judgment #6**
The NUT never forwards an Echo Reequest with IPsec ESP using the first negotiated algorithms.

**Step 14: Judgment #7**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 16: Judgment #8**
The NUT forwards an Echo Request.

**Step 18: Judgment #9**
The NUT forwards an Echo Reply with IPsec ESP using the first negotiated algorithms.

**Step 20: Judgment #10**
The NUT forwards an Echo Request.

**Step 22: Judgment #11**
The NUT forwards an Echo Reply with IPsec ESP using the second negotiated algorithms.

**Possible Problems:**

- None

## Group 2.8. Error Handling

### Test IKEv2.SGW.R.1.2.8.1: AUTHENTICATION_FAILED

This test case was deleted at revision 1.1.0.

# Group 2.9. Non zero RESERVED fields

## Test IKEv2.SGW.R.1.2.9.1: Non zero RESERVED fields in CREATE_CHILD_SA request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT               TN1
 (SGW)             (SGW)
   |                 |
   |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                 | (Packet #1)
   |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                 | (Judgment #1)
   |                 |
   |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                 | (Packet #2)
   |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                 | (Judgment #2)
   |                 |
   |<----------------| CREATE_CHILD_SA request (HDR, SK {N, SA, Ni, TSi, TSr})
   |                 | (Packet #3)
   |---------------->| CREATE_CHILD_SA response (HDR, SK {SA, Nr, TSi, TSr})
   |                 | (Judgment #3)
   V                 V

N: REKEY_SA
N+: USE_TRANSPORT_MODE
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #5 | See Common Packet #15<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits a CREATE_CHILD_SA request including a Notify Payload of type REKEY_SA and rekeyed CHILD_SA's SPI value in the SPI field to the NUT. All RESERVED fields are set to one.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits a CREATE_CHILD_SA response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

# Group 3. The INFORMATIONAL Exchange

## Group 3.1. Header and Payload Formats

### Test IKEv2.SGW.R.1.3.1.1: Sending INFORMATIONAL response

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.1.2 and 1.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |<----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                 | (Packet #1)
  |---------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                 | (Judgment #1)
  |                 |
  |<----------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                 | (Packet #2)
  |---------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                 | (Judgment #2)
  |                 |
  |<----------------| INFORMATION request (HDR, SK { })
  |                 | (Packet #3)
  |---------------->| INFORMATIONAL response (HDR, SK { })
  |                 | (Judgment #3)
  |                 |
  V                 V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #17 |

*Part A: IKE Header Format (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT_SA response from the NUT, TN1 transmits an

IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
6. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

7. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
8. Observe the messages transmitted on Link A.
9. After reception of IKE_SA_INIT_SA response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
10. Observe the messages transmitted on Link A.
11. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads to the NUT.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 7: Judgment #3**
The NUT transmits an INFORMATIONAL response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 171 Header format**

- An IKE_SA Initiator's SPI field set to same as the IKE_SA_INIT request's IKE_SA Initiator's SPI field value.
- An IKE_SA Responder's SPI field set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field set to Encrypted Payload (46).

- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to INFORMATIONAL (37).
- A Flags field set to (00000100)2 = (4)10.
- A Message ID field set to the same value as corresponding IKEv2 request message's Message ID.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 9: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 11: Judgment #2**

The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 14: Judgment #3**

The NUT transmits an INFORMATIONAL response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 172 Encrypted payload**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire

message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

**Possible Problems:**

- None.

## Group 3.2. Use of Retransmission Timers

### Test IKEv2.SGW.R.1.3.2.1: Receipt of retransmitted INFORMATIONAL request

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.1.2, 1.4 and 2.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
 (SGW)            (SGW)
   |                |
   |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                | (Packet #1)
   |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                | (Judgment #1)
   |                |
   |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                | (Packet #2)
   |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                | (Judgment #2)
   |                |
   |<---------------| INFORMATIONAL request (HDR, SK { })
   |                | (Packet #3)
   |--------------->| INFORMATIONAL response (HDR, SK { })
   |                | (Judgment #3)
   |                |
   |                * wait until retrans timer expires
   |--------------->| INFORMATIONAL response (HDR, SK { })
   |                | (Judgment #4)
   |                |
   |<---------------| INFORMATIONAL request (HDR, SK { })
   |                | (Packet #4)
   |--------------->| INFORMATIONAL response (HDR, SK { })
   |                | (Judgment #5)
   |                |
   V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #17 |

| Packet #4 | See Common Packet #17<br>(same Message ID as packet #3) |
|---|---|

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an INFORMATIONAL request with no payloads.
6. Observe the messages transmitted on Link A.
7. Observe the messages transmitted on Link A.
8. TN1 transmits an INFORMATIONAL request with no payloads. The Message ID is the same as Step 5.
9. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Step 7: Judgment #4**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Step 9: Judgment #5**
The NUT transmits an INFOMATIONAL response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

## Group 3.3. Non zero RESERVED fields

### Test IKEv2.SGW.R.1.3.3.1: Non RESERVED fields in INFORMATIONAL request

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.In addition, set IKE_SA Lifetime to 300 seconds and set CHILD_SA Lifetime to 30 seconds.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT                 TN1
 (SGW)               (SGW)
   |                   |
   |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
   |                   | (Packet #1)
   |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
   |                   | (Judgment #1)
   |                   |
   |<------------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
   |                   | (Packet #2)
   |------------------>| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
   |                   | (Judgment #2)
   |                   |
   |<------------------| INFORMATIONAL request (HDR, SK {})
   |                   | (Packet #3)
   |------------------>| INFORMATIONAL response (HDR, SK {})
   |                   | (Judgment #3)
   |                   |
   V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #17<br>All RESERVED fields are set to one. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_AUTH response from the NUT, TN1 transmits an IKE_AUTH

request to the NUT.
4. Observe the messages transmitted on Link A.
5. After reception of IKE_AUTH response from the NUT, TN1 transmits an INFORMATIONAL request with no payloads. All RESERVED fields in the message are set to one.
6. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as accepted algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as accepted algorithms.

**Step 6: Judgment #3**
The NUT transmits an INFOMATIONAL Response followed by an Encrypted payload with no payloads contained in it.

**Possible Problems:**

- None

# Group 4. RFC 5996

## Group 4.1. Rekeying IKE SAs Using a CREATE_HLD_SA Exchange

### [SGW.R.P29.L2503.ADD] Test IKEv2.SGW.R.1.4.1.1.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 5996] - Section 2.18

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |<---------------|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Packet #1)
  |                |--------------->|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Judgment #1)
  |                |                |                |
  |                |<---------------|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |--------------->|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}
  |                |                |                | (Packet #3) (Judgment #3)
  |----------------+================+--------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |
  |                |<---------------|                | CREATE_CHILD_SA request (HDR, SK {SA, Ni})
  |                |                |                | (Packet #5)
  |                |--------------->|                | CREATE_CHILD_SA response (HDR,
  |                |                |                |   SK {N(NO_PROPOSAL_CHOSEN)})
  |                |                |                | (Judgment #5)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

| | |
|---|---|
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common Packet #11 |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. TN1 transmits a CREATE_CHILD_SA request including a SA payload. A proposal in the SA payload contains 1 (IKE) in the Protocol ID field, 8 in the SPI size field and the rekeyed IKE_SA's initiator's SPI value. The proposal has the value "NONE" for the Diffie-Hellman transform.
10. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #4**
The NUT transmits a CREATE_CHILD_SA response with Notify payload of type NO_PROPOSAL_CHOSEN.

**Possible Problems:**

- None

## [SGW.R.P86.L4030.ADD.1] Test IKEv2.EN.R.1.4.1.2.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a proposal that contains a Transform Type it does not understand

**References:**

- [RFC 5996] - Section 3.3.6

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT               TN1
(SGW)             (SGW)
  |                 |
  |<----------------| IKE_SA_INIT request (HDR, SAi1(P1, P2), KEi, Ni)
  |                 | (Packet #1)
  |---------------->| IKE_SA_INIT response (HDR, SAr1(P2)), KEr, Nr)
  |                 | (Judgment #1)
  |                 |
  V                 V
P1: a proposal that contains 5 Transforms, "a Transform Type (240)",
    "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2"
P2: a proposal that contains 4 Transforms, "ENCR_3DES", "PRF_HMAC_SHA1",
    "AUTH_HMAC_SHA1_96", and "D-H Group 2"
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 2 SA Proposals. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 2 proposals. One proposal has 5 Transforms which are "a Transform Type (240)", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2". Another proposal has 4 Transforms which are "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [SGW.R.P86.L4030.ADD.2] Test IKEv2.EN.R.1.4.1.3.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a proposal that is missing a mandatory Transform Type

**References:**

- [RFC 5996] - Section 3.3.6

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1(P1, P2), KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1(P2), KEr, Nr)
  |                | (Judgment #1)
  |                |
  V                V
P1: a proposal that contains 3 Transforms, "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96",
    and "D-H Group 2"
P2: a proposal that contains 4 Transforms, "ENCR_3DES", "PRF_HMAC_SHA1",
    "AUTH_HMAC_SHA1_96",  and "D-H Group 2"
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 2 SA Proposals. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 2 proposals. One proposal has 3 Transforms which "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2". Another proposal has 4 Transforms which are "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", and "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [SGW.R.P86.L4034.ADD.1] Test IKEv2.EN.R.1.4.1.4.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a transform that it does not understand

**References:**

- [RFC 5996] - Section 3.3.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)              (SGW)
  |                  |
  |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  | (Packet #1)
  |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  | (Judgment #1)
  |                  |
  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1<br>IKE_SA_INIT request has 5 SA Transforms. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 5 Transforms which are "1 (ENCR) as Transform Type and 1023 as Transform ID", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2".
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [SGW.R.P86.L4034.ADD.2] Test IKEv2.EN.R.1.4.1.5.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a Transform Attribute it does not understand

**References:**

- [RFC 5996] - Section 3.3.5

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
  NUT              TN1
(End-Node)      (End-Node)
    |                |
    |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
    |                | (Packet #1)
    |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
    |                | (Judgment #1)
    |                |
    V                V
```

| | |
|---|---|
| Packet #1 | See Common Packt #1<br>IKE_SA_INIT request has 5 SA Transforms. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request. The request has 5 Transforms which are "ENCR_3DES with Transform Attribute of type KeyLength and value 192", "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96", "D-H Group 2"
2. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Possible Problems:**

- None

## [SGW.R.P57.L2663.ADD] Test IKEv2.EN.R.1.4.1.6.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can notify AUTHENTICATION_FAILED

**References:**

- [RFC 5996] - Section 2.21.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)            (SGW)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response { N(AUTHENTICATION_FAILED) }
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5<br>Authentication Data is 0x0123456789abcdef0123456789abcdef01234567. |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT. The response includes invalid Authentication Data 0x0123456789abcdef0123456789abcdef01234567.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including Notify payload of type AUTHENTICATION_FAILED.

**Possible Problems:**

- None

## [SGW.R.P69.L3234.ADD] Test IKEv2.EN.R.1.4.1.7.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CHILD_CHILD_SA request to close a Child SA that it is currently rekeying.

**References:**

- [RFC 5996] - Section 2.25.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1           NUT           TN1           TH2
(Host)        (SGW)         (SGW)         (Host)
  |             |             |             |
  |             |<------------|             | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |             |             |             | (Packet #1)
  |             |------------>|             | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |             |             |             | (Judgment #1)
  |             |             |             |
  |             |<------------|             | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |             |             |             | (Packet #2)
  |             |------------>|             | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |             |             |             | (Judgment #2)
  |             |             |             |
  |<------------+=============+-------------| IPsec {Echo Request}
  |             |             |             | (Packet #3) (Judgment #3)
  |-------------+=============+------------>| IPsec {Echo Reply}
  |             |             |             | (Packet #4) (Judgment #4)
  |             |             |             |
  |             |------------>|             | CREATE_CHILD_SA request (HDR,
  |             |             |             |   SK {N(REKEY_SA), SA, Ni, TSi, TSr})
  |             |             |             | (Judgment #5)
  |             |             |             |
  |             |<------------|             | INFORMATIONAL request (HDR, SK {D})
  |             |             |             | (Packet #5)
  |             |------------>|             | INFORMATIONAL response (HDR, SK {D})
  |             |             |             | (Judgment #6)
  V             V             V             V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protocol ID, 4 as SPI Size and SPI value to delete Child SA.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey a Child SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence

Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response. The response includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Possible Problems:**

- None

# [SGW.R.P69.L3252.ADD] Test IKEv2.EN.R.1.4.1.8.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process INFORMATIONAL request to close IKE SA that it is currently rekeying.

**References:**

- [RFC 5996] - Section 2.25.1

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1             NUT             TN1             TH2
(Host)          (SGW)           (SGW)           (Host)
  |               |               |               |
  |               |<--------------|               | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |               |               |               | (Packet #1)
  |               |-------------->|               | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |               |               |               | (Judgment #1)
  |               |               |               |
  |               |<--------------|               | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |               |               |               | (Packet #2)
  |               |-------------->|               | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |               |               |               | (Judgment #2)
  |               |               |               |
  |<--------------+===============+---------------| IPsec {Echo Request}
  |               |               |               | (Packet #3) (Judgment #3)
  |---------------+===============+-------------->| IPsec {Echo Reply}
  |               |               |               | (Packet #4) (Judgment #4)
  |               |               |               |
  |               |-------------->|               | CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
  |               |               |               | (Judgment #5)
  |               |               |               |
  |               |<--------------|               | INFORMATIONAL request (HDR, SK {D})
  |               |               |               | (Packet #5)
  |               |-------------->|               | INFORMATIONAL response (HDR, SK {})
  |               |               |               | (Judgment #6)
  |               |               |               |
  |               |-------X       |               | CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
  |               |               |               | (Judgment #7)
  V               V               V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |

| | |
|---|---|
| Packet #4 | See Common Packet #25 |
| Packet #5 | See Common below |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 16 |
| | Procotol ID | 1 (IKE_SA) |
| | SPI Size | 0 |
| | # of SPIs | 0 |
| | Security Parameter Index(es) (SPI) | empty |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 1 (IKE) as Protocol ID, zero as SPI Size and no SPI value.
12. Observe the messages transmitted on Link A.
13. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**

The NUT transmits a CREATE_CHILD_SA request to rekey IKE SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response with no payloads.

**Step 13: Judgment #7**
The NUT does not retransmit a CREATE_CHILD_SA request to rekey a Child SA.

**Possible Problems:**

- None

## [SGW.R.P69.L3258.ADD] Test IKEv2.EN.R.1.4.1.9.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CREATE_CHILD_SA request to rekey a Child SA when it is currently rekeying the IKE SA.

**References:**

- [RFC 5996] - Section 2.5.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1          NUT          TN1          TH2
(Host)       (SGW)        (SGW)        (Host)
  |            |            |            |
  |            |<-----------|            | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |            |            |            | (Packet #1)
  |            |----------->|            | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |            |            |            | (Judgment #1)
  |            |            |            |
  |            |<-----------|            | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |            |            |            | (Packet #2)
  |            |----------->|            | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |            |            |            | (Judgment #2)
  |            |            |            |
  |<-----------+============+------------| IPsec {Echo Request}
  |            |            |            | (Packet #3) (Judgment #3)
  |------------+============+----------->| IPsec {Echo Reply}
  |            |            |            | (Packet #4) (Judgment #4)
  |            |            |            |
  |            |----------->|            | CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
  |            |            |            | (Judgment #5)
  |            |            |            |
  |            |<-----------|            | CREATE_CHILD_SA request (HDR,
  |            |            |            |   SK {N(REKEY_SA), SA, Ni, TSi, TSr})
  |            |            |            | (Packet #5)
  |            |----------->|            | CREATE_CHILD_SA response (HDR, SK {N(TEMPORARY_FAILURE)})
  |            |            |            | (Judgment #6)
  |            |            |            |
  V            V            V            V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |

| Packet #5 | See Common Packet #11 |
|---|---|

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
10. Observe the messages transmitted on Link A.
11. TN1 transmits a CREATE_CHILD_SA request to rekey a Child SA. The request includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT transmits a CREATE_CHILD_SA request to rekey a Child SA. The message includes "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. And the CREATE_CHILD_SA request includes a Notify payload of type REKEY_SA containing rekeyed CHILD_SA's SPI value in the SPI field.

**Step 12: Judgment #6**
The NUT transmits a CREATE_CHILD_SA response. The response includes a Notify payload of type TEMPORRAY_FAILURE.

**Possible Problems:**

- None

## [SGW.R.P69.L3260.ADD] Test IKEv2.EN.R.1.4.1.10.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can process CREATE_CHILD_SA request to delete a Child SA when it is currently rekeying the IKE SA

**References:**

- [RFC 5996] - Section 2.5.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1              TH2
(Host)           (SGW)            (SGW)            (Host)
  |                |                |                |
  |                |<---------------|                | IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                |                | (Packet #1)
  |                |--------------->|                | IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                |                | (Judgment #1)
  |                |                |                |
  |                |<---------------|                | IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |                |                | (Packet #2)
  |                |--------------->|                | IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |                |                | (Judgment #2)
  |                |                |                |
  |<---------------+================+----------------| IPsec {Echo Request}
  |                |                |                | (Packet #3) (Judgment #3)
  |----------------+================+--------------->| IPsec {Echo Reply}
  |                |                |                | (Packet #4) (Judgment #4)
  |                |                |                |
  |                |--------------->|                | CREATE_CHILD_SA request (HDR, SK {SA, Ni, KEi})
  |                |                |                | (Judgment #5)
  |                |                |                |
  |                |<---------------|                | INFORMATIONAL request (HDR, SK {D})
  |                |                |                | (Packet #5)
  |                |--------------->|                | INFORMATIONAL response (HDR, SK {D})
  |                |                |                | (Judgment #6)
  |                |                |                |
  V                V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |
| Packet #3 | See Common Packet #21 |
| Packet #4 | See Common Packet #25 |
| Packet #5 | See below |

- Packet #5: INFORMATIONAL request

| | | |
|---|---|---|
| IPv6 Header | Same as the Common Packet #17 | |
| UDP Header | Same as the Common Packet #17 | |
| IKEv2 Header | Same as the Common Packet #17 | |
| E Payload | Other fields are same as the Common Packet #17 | |
| | Next Payload | 42 (Delete) |
| Delete Payload | Next Payload | 0 (last) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | Procotol ID | 3 (ESP) |
| | SPI Size | 4 |
| | # of SPIs | 1 |
| | Security Parameter Index(es) (SPI) | SPI negotiated by Initial Exchange |

*Part A: (BASIC)*

1. TN1 starts to negotiate with NUT by sending IKE_SA_INIT request.
2. Observe the messages transmitted on Link A.
3. After reception of IKE_SA_INIT response from the NUT, TN1 transmits an IKE_AUTH request to the NUT.
4. Observe the messages transmitted on Link A.
5. TH2 transmits an Echo Request to TH1.
6. Observe the messages transmitted on Link B.
7. TH1 transmits an Echo Reply to TH2.
8. Observe the messages transmitted on Link A.
9. Repeat Steps 5 and 6 until lifetime of SA is expired for 30 seconds.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.
12. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
TN1 transmits an INFORMATIONAL request. The request includes a Delete payload with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Step 12: Judgment #6**
The NUT transmits an INFORMATIONAL response with 3 (ESP) as Protcol ID, 4 as SPI Size and SPI value to delete Child SA.

**Possible Problems:**

- None

Section 2.2.2. Endpoint to Security Gateway Tunnel
Group 1. The Initial Exchanges

# Group 1.1. Header and Payload Formats

## Test IKEv2.SGW.R.2.1.1.1: Sending IKE_AUTH response

**Purpose:**

To verify an IKEv2 device transmits IKE_AUTH request using properly Header and Payloads format

**References:**

- [RFC 4306] - Sections 1.2, 2.15, 3.1, 3.2, 3.3, 3.5, 3.8, 3.10, 3.13 and 3.14

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT              TN1
(SGW)          (End-Node)
  |                |
  |<---------------|  IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |  (Packet #1)
  |--------------->|  IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |  (Judgment #1)
  |                |
  |<---------------|  IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |  (Packet #2)
  |--------------->|  IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |  (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5 |

*Part A: IKE Header Format (BASIC)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to NUT.
4. Observe the messages transmitted on Link A.

*Part B: Encrypted Payload Format (BASIC)*

5. TN1 transmits an IKE_SA_INIT request to NUT.
6. Observe the messages transmitted on Link A.
7. TN1 transmits an IKE_SA_INIT request to NUT.

8. Observe the messages transmitted on Link A.

*Part C: IDr Payload Format (BASIC)*

9. TN1 transmits an IKE_SA_INIT request to NUT.
10. Observe the messages transmitted on Link A.
11. TN1 transmits an IKE_SA_INIT request to NUT.
12. Observe the messages transmitted on Link A.

*Part D: AUTH Payload Format (BASIC)*

13. TN1 transmits an IKE_SA_INIT request to NUT.
14. Observe the messages transmitted on Link A.
15. TN1 transmits an IKE_SA_INIT request to NUT.
16. Observe the messages transmitted on Link A.

*Part E: SA Payload Format (BASIC)*

17. TN1 transmits an IKE_SA_INIT request to NUT.
18. Observe the messages transmitted on Link A.
19. TN1 transmits an IKE_SA_INIT request to NUT.
20. Observe the messages transmitted on Link A.

*Part F: TSi Payload Format (BASIC)*

21. TN1 transmits an IKE_SA_INIT request to NUT.
22. Observe the messages transmitted on Link A.
23. TN1 transmits an IKE_SA_INIT request to NUT.
24. Observe the messages transmitted on Link A.

*Part G: TSr Payload Format (BASIC)*

25. TN1 transmits an IKE_SA_INIT request to NUT.
26. Observe the messages transmitted on Link A.
27. TN1 transmits an IKE_SA_INIT request to NUT.
28. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted IKE Header containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Initiator's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                       IKE_SA Responder's SPI                  !
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!  Next Payload ! MjVer ! MnVer ! Exchange Type !     Flags     !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                          Message ID                           !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                            Length                             !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 173 Header format**

- An IKE_SA Initiator's SPI field set to same as the IKE_SA_INIT request's IKE_SA Initiator's SPI field value.
- An IKE_SA Responder's SPI field set to same as the IKE_SA_INIT response's IKE_SA Responder's SPI field value.
- A Next Payload field set to Encrypted Payload (46).
- A Major Version field set to 2.
- A Minor Version field set to zero.
- An Exchange Type field set to IKE_AUTH (35).
- A Flags field set to (00010000)2 = (16)10.
- A Message ID field set to 1.
- A Length field set to the length of the message (header + payloads) in octets.

*Part B*

**Step 6: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 8: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted Encrypted Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                     Initialization Vector                     !
!         (length is block size for encryption algorithm)       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Encrypted IKE Payloads                     ~
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!               !             Padding (0-255 octets)            !
+-+-+-+-+-+-+-+-+                               +-+-+-+-+-+-+-+-+
!                                               !  Pad Length   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    Integrity Checksum Data                    ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 174 Encrypted payload**

- A Next Payload field set to IDr Payload (36).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length in octets of the header, IV, Encrypted IKE Payloads, Padding, Pad Length, and Integrity Check sum Data.
- An Initialization Vector field set to a randomly chosen value whose length is equal to the block length of the underlying encryption algorithm. It is 64 bits length in ENCR_3DES case.
- An Encrypted IKE Payloads field set to subsequent payloads encrypted by ENCR_3DES.
- A Padding field set to any value which to be a multiple of the encryption block size. It is 64 bits length in ENCR_3DES case.
- A Pad Length field set to the length of the Padding field.
- An Integrity Checksum Data set to the cryptographic checksum of the entire message. It is 96 bits length in AUTH_HMAC_SHA1_96 case. The checksum must be valid by calculation according to the manner described in RFC.

*Part C*

**Step 10: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 12: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted ID Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   ID Type     !                 RESERVED                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Identification Data                         ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 175 ID Payload format**

- A Next Payload field set to AUTH Payload (39).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 24 bytes for ID_IPV6_ADDR.
- An ID Type field set to ID_IPV6_ADDR (5).
- A RESERVED field set to zero.
- An Identification Data field set to the NUT address.

*Part D*

**Step 14: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 16: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Auth Method   !                RESERVED                       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Authentication Data                      ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 176 AUTH Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload. It is 28 bytes for PRF_HMAC_SHA1.
- An Auth Method field set to Shared Key Message Integrity Code (2).
- A RESERVED field set to zero.
- An Authentication Data field set to correct authentication value according to the manner described in RFC. It is 160 bytes length in PRF_HMAC_SHA1 case.

*Part E*

**Step 18: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 20: Judgment #2**

```
                      1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
 ! Next     44    !0!      0       ! Length           40            !               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---           |
 !      0         !        0       ! Length           36            !  |            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
 ! Number     1   ! Prot ID    3   ! SPI Size   4   ! Trans Cnt  3  !  |            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
 ! SPI value                                                        !  |            |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
          | !      3         !        0       ! Length            8            !  |            |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |SA Payload
          | ! Type  1  (EN) !        0       ! Transform ID      3      (3DES) !  | Proposal |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
          | !      3         !        0       ! Length            8            !  |            |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
          | ! Type  3  (IN) !        0       ! Transform ID      2      (SHA1) !  |            |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
          | !      0         !        0       ! Length            8            !  |            |
Transform | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  |            |
          | ! Type  5  (ESN)!        0       ! Transform ID      0       (No)   !  |            |
--- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ --------------
```

**Figure 177 SA Payload contents**

The NUT transmits an IKE_AUTH response including properly formatted SA Payload containing following values (refer following figures):

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                          <Proposals>                          ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 178 SA Payload format**

- A Next Payload field set to TSi Payload (44).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.

A Proposals field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 2 !   RESERVED    !         Proposal Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Proposal #    !  Protocol ID  !    SPI Size   !# of Transforms!
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                        SPI (variable)                         ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                        <Transforms>                           ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 179 Proposal sub-structure format**

Proposal #1

- A 0 or 2 field set to zero (last).
- A RESREVD field set to zero.
- A Proposal Length field set to length of this proposal, including all transforms and attributes. It is 36 bytes according to Common Configuration.
- A Proposal # field set to 1.
- A Protocol ID field set to ESP (3).
- A SPI Size field set to 4.
- A # of Transforms field set to 3.
- A SPI field set to the sending entity’s SPI (4 octets value)

Transform field set to following (There are 3 Transform Structures).

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! 0 (last) or 3 !   RESERVED    !        Transform Length       !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!Transform Type !   RESERVED    !          Transform ID         !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                      Transform Attributes                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 180 Transform sub-structure format**

Transform #1

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ENCR_3DES.
- A Transform Type field set to ENCR (1).
- A RESERVED field set to zero.
- A Transform ID set to ENCR_3DES (3).

Transform #2

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including

Header and Attribute. It is 8 bytes for AUTH_HMAC_SHA1.

- A Transform Type field set to INTEG (3).
- A RESERVED field set to zero.
- A Transform ID set to AUTH_HMAC_SHA1 (2).

Transform #3

- A 0 or 3 field set to zero if this structure is the last transform, otherwise set to 3.
- A RESERVED field set to zero.
- A Transform Length set to length of the Transform Substructure including Header and Attribute. It is 8 bytes for ESN.
- A Transform Type field set to ESN (5).
- A RESERVED field set to zero.
- A Transform ID set to No Extended Sequence Numbers (0).

*Part F*

**Step 22: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 24: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted TSi Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 181 TSi Payload format**

- A Next Payload field set to TSr Payload (45).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 182 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to TN1 address.
- A Ending Address field set to greater thatn or equal to TN1 address.

*Part G*

**Step 26: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 28: Judgment #2**
The NUT transmits an IKE_AUTH response including properly formatted TSr Payload containing following values:

```
                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C!  RESERVED   !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Number of TSs !                 RESERVED                      !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                       <Traffic Selectors>                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 183 TSr Payload format**

- A Next Payload field set to zero.
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A Number of TSs field set to 1.
- A RESERVED field set to zero.

Traffic Selectors field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   TS Type     !IP Protocol ID*|       Selector Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Start Port*         |           End Port*           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Starting Address*                     ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                         Ending Address*                       ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 184 Traffic Selector**

- A TS Type set to TS_IPV6_ADDR_RANGE (8).
- An IP Protocol ID field set to zero.
- A Selector Length field set to length of this Traffic Selector Substructure including the header. It is 40 bytes for TS_IPV6_ADDR_RANGE.
- A Start Port field set to zero.
- An End Port field set to 65535.
- A Starting Address field set to less than or equal to Prefix B.
- An Ending Address field set to less than or equal to Prefix B.

**Possible Problems:**

- IKE_AUTH response has following packet format.It may have additional payloads described below. Additional payloads can be ignored by this test. The order of payload may be different from this sample.

```
IDr, [CERT+],
AUTH,
[CP(CFG_REPLY)],
[N(IPCOMP_SUPPORTED)],
[N(USE_TRANSPORT_MODE)],
[N(ESP_TFC_PADDING_NOT_SUPPORTED)],
[N(NON_FIRST_FRAGMENTS_ALSO)],
SA, TSi, TSr,
[N(ADDITIONAL_TS_POSSIBLE)],
[V+]
```

- Each of transforms can be located in the any order.

## Test IKEv2.SGW.R.2.1.1.2: Use of CHILD_SA

**Purpose:**

To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 1.2

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT             TN1
(Host)           (SGW)         (End-Node)
  |                |               |
  |                |<--------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |               | (Packet #1)
  |                |-------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |               | (Judgment #1)
  |                |               |
  |                |<--------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                |               | (Packet #2)
  |                |-------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, SAr2, TSi, TSr})
  |                |               | (Judgment #2)
  |                |               |
  |<---------------+===============| IPsec {Echo Request}
  |                |               | (Judgment #3)
  |----------------+==============>| IPsec {Echo Reply}
  |                |               | (Judgment #4)
  |                |               |
  V                V               V
```

| | |
|---|---|
| Packet #1 | See Common Packet #2 |
| Packet #2 | See Common Packet #6 |

*Part A (BASIC)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT response to NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to TH1.
6. Observe the messages transmitted on Link A.
7. TH1 transmits an Echo Reply to TN1.
8. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request.

**Step 8 Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- None.

## Group 1.2. Requesting an Internal Address on a Remote Network

### Test IKEv2.SGW.R.2.1.2.1: Receipt of CFG_REQUEST

**Purpose:**

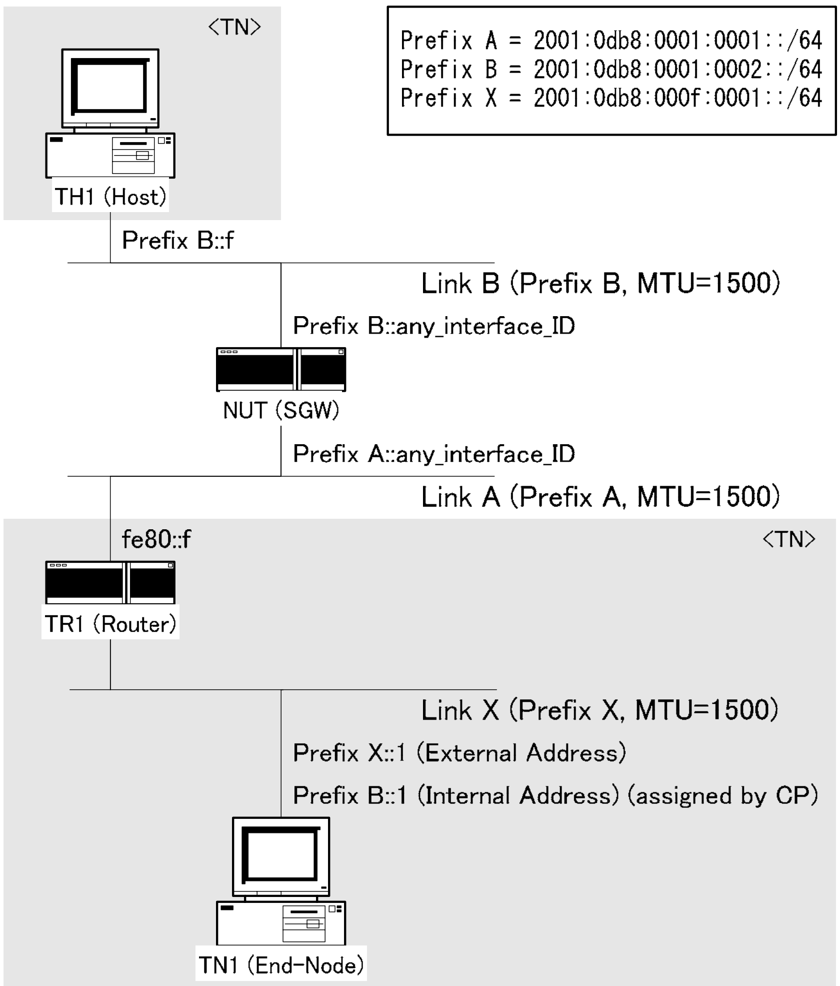
To verify an IKEv2 device transmits IKE_AUTH request using properly eader and Configuration Payload format

**References:**

- [RFC 4306] - Sections 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic

selector. Configure NUT to transmit CFG_REPLY for INTERNAL_IP6_ADDRESS. Its IPv6 address is Prefix B::1/128. The traffic selector must be configured by the following table. NUT must narrow Traffic Selector to the following address range.

| | **Traffic Selector** | | | | | |
|---|---|---|---|---|---|---|
| | **Source** | | | **Destination** | | |
| | **Address Range** | **Next Layer Protocol** | **Port Range** | **Address Range** | **Next Layer Protocol** | **Port Range** |
| **Inbound** | TN1 (internal address) | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 (internal address) | ANY | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)            (End-Node)
  |                   |
  |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   | (Packet #1)
  |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   | (Judgment #1)
  |                   |
  |<------------------| IKE_AUTH request (HDR, SK {IDi, AUTH, CP(CFG_REQUEST), SAi2, TSi, TSr})
  |                   | (Packet #2)
  |------------------>| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
  |                   | (Judgment #2)
  |                   |
  V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

- Packet #2: IKE_AUTH request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #5 | |
| UDP Header | Same as Common Packet #5 | |
| IKEv2 Header | Same as Common Packet #5 | |
| E Payload | Same as Common Packet #5 | |
| IDi Payload | Same as Common Packet #5 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #5 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | CFG Type | 1 (CFG_REQUEST) |
| | RESERVED | 0 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #5 | |
| TSi Payload | Other fields are same as Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #5 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 0 |
| | Attribute Type | INTERNAL_IP6_ADDRESS |
| | Length | 0 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | :: |
| | Ending Address | ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff |

*Part A: (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH response including properly formatted AUTH Payload containing following values:

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
! Next Payload  !C! RESERVED    !         Payload Length        !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!   CFG Type    !                    RESERVED                   !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!                                                               !
~                   Configuration Attributes                    ~
!                                                               !
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 185 Configuration Payload format**

- A Next Payload field set to SA Payload (33).
- A Critical field set to zero.
- A RESERVED field set to zero.
- A Payload Length field set to length of the current payload.
- A CFG Type field set to CFG_REPLY (2).
- A RESERVED field set to zero.

A Configuration Attributes field set to following.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
!R|         Attribute Type      !            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                             Value                             ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

**Figure 186 Configuration Attributes format**

Configuration Attribute #1

- Reserved field is set to zero.
- Attribute Type field is set to INTERNAL_IP6_ADDRESS (8).
- Length field is set to 17.
- Value field is set to Prefix B::1 as IPv6 address and 128 as prefix-length.

**Possible Problems:**

- None.

# Test IKEv2.SGW.R.2.1.2.2: Use of CHILD_SA

**Purpose:**

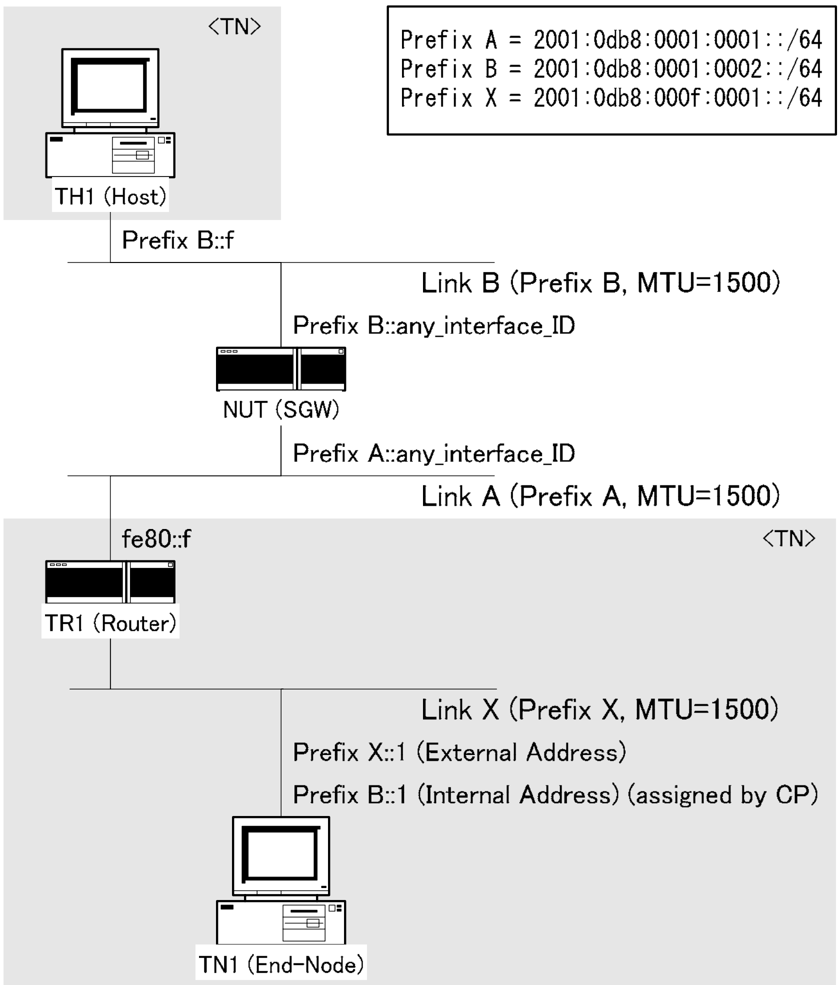
To verify an IKEv2 device properly handles the Initial Exchanges using Pre-shared key

**References:**

- [RFC 4306] - Sections 2.19 and 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REPLY for INTERNAL_IP6_ADDRESS. Its IPv6 address is Prefix B::1/128. The traffic selector must be configured by the following table. NUT must narrow Traffic Selector to the following address table.

| | **Traffic Selector** |
|---|---|

| | Source | | | Destination | | |
|---|---|---|---|---|---|---|
| | **Address Range** | **Next Layer Protocol** | **Port Range** | **Address Range** | **Next Layer Protocol** | **Port Range** |
| **Inbound** | TN1 (internal address) | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 (internal address) | ANY | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                    NUT                 TN1
(Host)                 (SGW)            (End-Node)
  |                      |                    |
  |                      |<-------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                      |                    | (Packet #1)
  |                      |------------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                      |                    | (Judgment #1)
  |                      |                    |
  |                      |<-------------------| IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                      |                    |                     CP(CFG_REQUEST), SAi2, TSi, TSr})
  |                      |                    | (Packet #2)
  |                      |------------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
  |                      |                    | (Judgment #2)
  |                      |                    |
  |<---------------------+====================| IPsec {Echo Request}
  |                      |                    | (Packet #3) (Judgment #3)
  |----------------------+===================>| IPsec {Echo Reply}
  |                      |                    | (Packet #4) (Judgment #4)
  |                      |                    |
  V                      V                    V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See below |

- Packet #2: IKE_AUTH request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #5 | |
| UDP Header | Same as Common Packet #5 | |
| IKEv2 Header | Same as Common Packet #5 | |
| E Payload | Same as Common Packet #5 | |
| IDi Payload | Same as Common Packet #5 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #5 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |
| | Payload Length | 12 |
| | CFG Type | 1 (CFG_REQUEST) |
| | RESERVED | 0 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #5 | |
| TSi Payload | Other fields are same as Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #5 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 0 |
| | Attribute Type | INTERNAL_IP6_ADDRESS |
| | Length | 0 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | :: |
| | Ending Address | ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff |

- Packet #3: Echo Request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #22 | |
| ESP | Same as Common Packet #22 | |
| IPv6 Header | Source Address | Prefyx B::1 |
| | Destination Address | Prefix B::f |
| ICMPv6 Header | Same as Common Packet #22 | |

- Packet #4: Echo Reply packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | Prefyx B::f |
| | Destination Address | Prefix B::1 |
| ICMPv6 Header | Same as Common Packet #26 | |

*Part A (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to TH1.
6. Observe the messages transmitted on Link A.
7. TH1 transmits an Echo Reply to TN1.
8. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request to the TH1.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- Because the destination address of  Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TN1 can send Echo Reply to TH1 instead of sending Echo Request.

## Test IKEv2.SGW.R.2.1.2.3: Non zero RESERVED fields in Configuration Payload

**Purpose:**

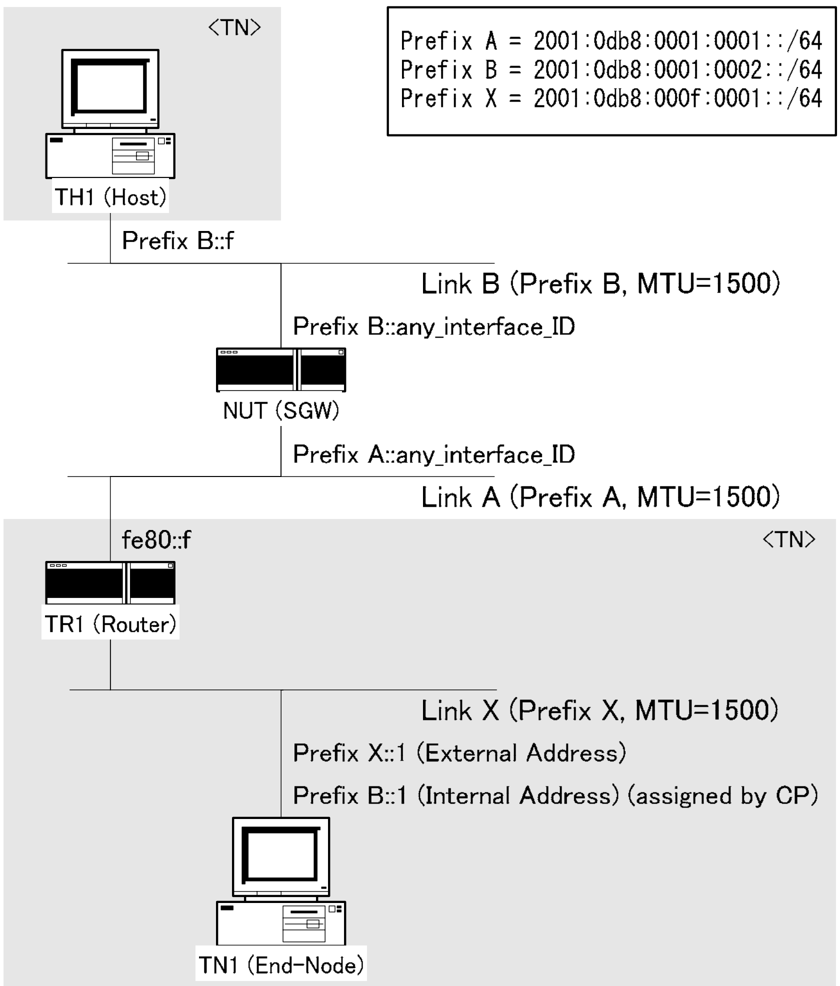
To verify an IKEv2 device ignores the content of RESERVED filed in IKE messages.

**References:**

- [RFC 4306] - Sections 2.5

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REPLY for INTERNAL_IP6_ADDRESS. Its IPv6 address is Prefix B::1/128. The traffic selector must be configured by the following table. NUT must narrow Traffic Selector to the following address table.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 (internal address) | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 (internal address) | ANY | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1                NUT                TN1
(Host)             (SGW)            (End-Node)
  |                  |                  |
  |                  |<-----------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                  |                  | (Packet #1)
  |                  |----------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                  |                  | (Judgment #1)
  |                  |                  |
  |                  |<-----------------| IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                  |                  |                       CP(CFG_REQUEST), SAi2, TSi, TSr})
  |                  |                  | (Packet #2)
  |                  |----------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
  |                  |                  | (Judgment #2)
  |                  |                  |
  V                  V                  V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |

- Packet #2: IKE_AUTH request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #5 | |
| UDP Header | Same as Common Packet #5 | |
| IKEv2 Header | Same as Common Packet #5 | |
| E Payload | Same as Common Packet #5 | |
| IDi Payload | Same as Common Packet #5 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #5 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 1 |
| | Payload Length | 12 |
| | CFG Type | 1 (CFG_REQUEST) |
| | RESERVED | 1 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #5 | |
| TSi Payload | Other fields are same as Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #5 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 1 |
| | Attribute Type | INTERNAL_IP6_ADDRESS |
| | Length | 0 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |

| | | |
|---|---|---|
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | :: |
| | Ending Address | ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff |

*Part A (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Possible Problems:**

- None.

## Test IKEv2.SGW.R.2.1.2.4: No Configuration payload

**Purpose:**

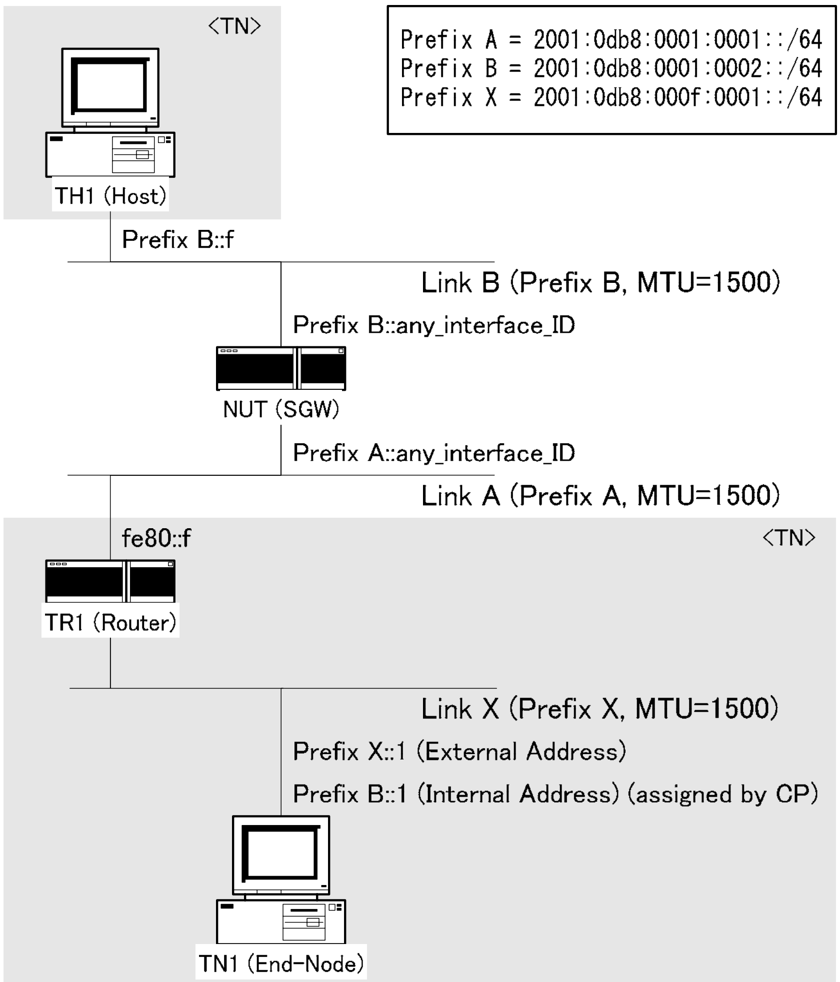
To verify an IKEv2 device properly handles the message which does not include Configuration payload, when the device expects Configuration payload.

**References:**

- [RFC 4306] - Sections 2.19 and 3.10.1

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REPLY for INTERNAL_IP6_ADDRESS. Its IPv6 address is Prefix B::1/128. The traffic selector must be configured by the following table. NUT must narrow Traffic Selector to the following address table.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | **Source** | | | **Destination** | | |
| | **Address Range** | **Next Layer Protocol** | **Port Range** | **Address Range** | **Next Layer Protocol** | **Port Range** |
| **Inbound** | TN1 (internal address) | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 (internal address) | ANY | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 NUT                TN1
(SGW)            (End-Node)
  |                   |
  |<------------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                   | (Packet #1)
  |------------------>| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                   | (Judgment #1)
  |                   |
  |<------------------| IKE_AUTH request (HDR, SK {IDi, AUTH, SAi2, TSi, TSr})
  |                   | (Packet #2)
  |------------------>| IKE_AUTH response (HDR, SK {N(FAILED_CP_REQUIRED)})
  |                   | (Judgment #2)
  |                   |
  V                   V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5<br>This packet does not include CP payload. |

*Part A (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response with a Notify payload of type FAILED_CP_REQUIRED.

**Possible Problems:**

- None.

# Test IKEv2.SGW.R.2.1.2.5: Receipt of Multiple CFG_REQUEST

**Purpose:**

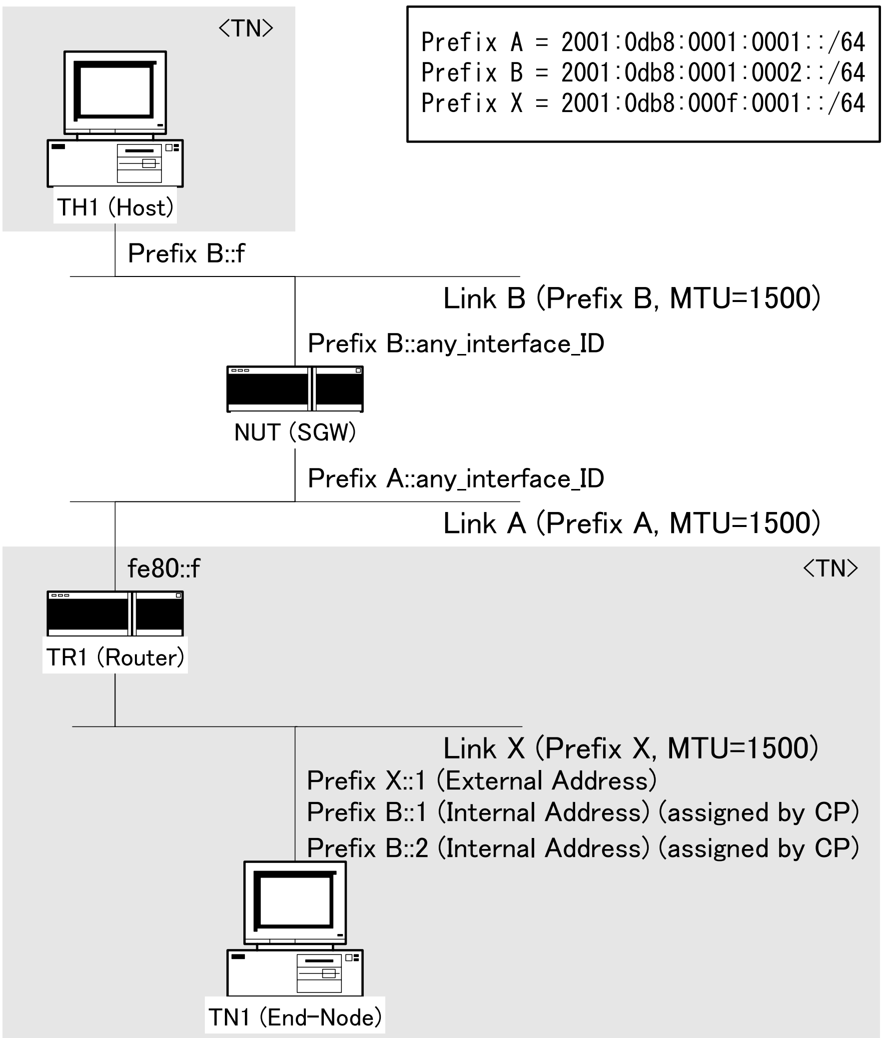
To verify an IKEv2 device properly handles multiple CFG_REQUEST.

**References:**

- [RFC 4306] - Sections 2.19 and 3.15

**Test Setup:**

- Network Topology
  Connect the devices according to the following topology.




- Configuration
  In each part, configure NUT according to the Common Configuration except the traffic selector. Configure NUT to transmit CFG_REPLY for INTERNAL_IP6_ADDRESS. Its IPv6 address is Prefix B::1/128. The traffic selector must be configured by the following table. NUT must narrow Traffic Selector to the following address table.

| | Traffic Selector | | | | | |
|---|---|---|---|---|---|---|
| | Source | | | Destination | | |
| | Address Range | Next Layer Protocol | Port Range | Address Range | Next Layer Protocol | Port Range |
| **Inbound** | TN1 (internal address) | ANY | ANY | Link B | ANY | ANY |
| **Outbound** | Link B | ANY | ANY | TN1 (internal address) | ANY | ANY |

- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
 TH1              NUT              TN1
(Host)           (SGW)          (End-Node)
  |                |                |
  |                |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                |                | (Packet #1)
  |                |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                |                | (Judgment #1)
  |                |                |
  |                |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH,
  |                |                |                          CP(CFG_REQUEST), SAi2, TSi, TSr})
  |                |                | (Packet #2)
  |                |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
  |                |                | (Judgment #2)
  |                |                |
  |<---------------+================| IPsec {Echo Request}
  |                |                | (Packet #3) (Judgment #3)
  |----------------+===============>| IPsec {Echo Reply}
  |                |                | (Packet #4) (Judgment #4)
  |                |                |
  |<---------------+================| IPsec {Echo Request}
  |                |                | (Packet #5) (Judgment #5)
  |----------------+===============>| IPsec {Echo Reply}
  |                |                | (Packet #6) (Judgment #6)
  |                |                |
  V                V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See below |
| Packet #3 | See below |
| Packet #4 | See below |
| Packet #5 | See below |
| Packet #6 | See below |

- Packet #2: IKE_AUTH request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #5 | |
| UDP Header | Same as Common Packet #5 | |
| IKEv2 Header | Same as Common Packet #5 | |
| E Payload | Same as Common Packet #5 | |
| IDi Payload | Same as Common Packet #5 | |
| AUTH Payload | Next Payload | 47 (CP) |
| | Other fields are same as Common Packet #5 | |
| CP Payload | Next Payload | 33 (SA) |
| | Critical | 0 |
| | Reserved | 0 |

| | | |
|---|---|---|
| | Payload Length | 16 |
| | CFG Type | 1 (CFG_REQUEST) |
| | RESERVED | 0 |
| | Configuration Attributes | See below |
| SA Payload | Same as Common Packet #5 | |
| TSi Payload | Other fields are same as Common Packet #5 | |
| | Traffic Selectors | See below |
| TSr Payload | Same as Common Packet #5 | |

| | | |
|---|---|---|
| Configuration Attributes | Reserved | 0 |
| | Attribute Type | INTERNAL_IP6_ADDRESS |
| | Length | 0 |
| Configuration Attributes | Reserved | 0 |
| | Attribute Type | INTERNAL_IP6_ADDRESS |
| | Length | 0 |

| | | |
|---|---|---|
| Traffic Selector | TS Type | 8 (IPV6_ADDR_RANGE) |
| | IP Protocol ID | 0 (any) |
| | Selector Length | 40 |
| | Start Port | 0 |
| | End Port | 65535 |
| | Starting Address | :: |
| | Ending Address | ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff |

- Packet #3: Echo Request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #22 | |
| ESP | Same as Common Packet #22 | |
| IPv6 Header | Source Address | Prefyx B::1 |
| | Destination Address | Prefix B::f |
| ICMPv6 Header | Same as Common Packet #22 | |

- Packet #4: Echo Reply packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | Prefyx B::f |
| | Destination Address | Prefix B::1 |
| ICMPv6 Header | Same as Common Packet #26 | |

- Packet #5: Echo Request packet

| | | |
|---|---|---|
| IPv6 Header | Same as Common Packet #22 | |
| ESP | Same as Common Packet #22 | |
| IPv6 Header | Source Address | Prefyx B::2 |
| | Destination Address | Prefix B::f |
| ICMPv6 Header | Same as Common Packet #22 | |

- Packet #6: Echo Reply packet

| | | |
|---|---|---|
| IPv6 Header | Source Address | Prefyx B::f |
| | Destination Address | Prefix B::2 |
| ICMPv6 Header | Same as Common Packet #26 | |

*Part A (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to the NUT.
4. Observe the messages transmitted on Link A.
5. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to TH1.

6. Observe the messages transmitted on Link A.
7. TH1 transmits an Echo Reply to TN1.
8. Observe the messages transmitted on Link B.
9. TN1 transmits an Echo Request with IPsec ESP using corresponding algorithms to TH1.
10. Observe the messages transmitted on Link A.
11. TH1 transmits an Echo Reply to TN1.
12. Observe the messages transmitted on Link B.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**
The NUT transmits an IKE_SA_INIT response including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**
The NUT transmits an IKE_AUTH response including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms.

**Step 6: Judgment #3**
The NUT forwards an Echo Request to the TH1.

**Step 8: Judgment #4**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Step 10: Judgment #5**
The NUT forwards an Echo Request to the TH1.

**Step 12: Judgment #6**
The NUT forwards an Echo Reply with IPsec ESP using corresponding algorithms.

**Possible Problems:**

- Because the destination address of Echo Request is the TN itself, TN may respond to Echo Request automatically. In that case, TN1 can send Echo Reply to TH1 instead of sending Echo Request.

## Group 2. RFC 5996

## Group 2.1. Rekeying IKE SAs Using a CREATE_HLD_SA Exchange

### [SGW.R.P116.L5437.ADD] Test IKEv2.SGW.R.2.2.1.1.XXX: Sending INFORMATIONAL Exchange

**Purpose:**

To verify an IKEv2 device can handle a particular type of address that the device does not support

**References:**

- [RFC 5996] - Section 3.15.4

**Test Setup:**

- Network Topology
  Connect the devices according to the Common Topology.
- Configuration
  In each part, configure the devices according to the Common Configuration.
- Pre-Sequence and Cleanup Sequence
  IKEv2 on the NUT is disabled after each part.

**Procedure:**

```
NUT              TN1
(SGW)         (End-Node)
  |                |
  |<---------------| IKE_SA_INIT request (HDR, SAi1, KEi, Ni)
  |                | (Packet #1)
  |--------------->| IKE_SA_INIT response (HDR, SAr1, KEr, Nr)
  |                | (Judgment #1)
  |                |
  |<---------------| IKE_AUTH request (HDR, SK {IDi, AUTH, CP(CFG_REQUEST), SAi2, TSi, TSr})
  |                | (Packet #2)
  |--------------->| IKE_AUTH response (HDR, SK {IDr, AUTH, CP(CFG_REPLY), SAr2, TSi, TSr})
  |                | (Judgment #2)
  |                |
  V                V
```

| | |
|---|---|
| Packet #1 | See Common Packet #1 |
| Packet #2 | See Common Packet #5<br>Configuration payload has 2 Configuration Attributes.<br>One is Attribute Type is INTERNAL_IP4_Address.<br>Another is Attribute Type is INTERNAL_IP6_Address. |

*Part A: (ADVANCED)*

1. TN1 transmits an IKE_SA_INIT request to NUT.
2. Observe the messages transmitted on Link A.
3. TN1 transmits an IKE_SA_INIT request to NUT. The request has 2 Configuration

Attributes. One is Attribute Type of INTERNAL_IP4_ADDRESS. Another is Attribute Type of INTERNAL_IP6_ADDRESS.

4. Observe the messages transmitted on Link A.

**Observable Results:**

*Part A*

**Step 2: Judgment #1**

The NUT transmits an IKE_SA_INIT request including "ENCR_3DES", "PRF_HMAC_SHA1", "AUTH_HMAC_SHA1_96" and "D-H Group 2" as proposed algorithms.

**Step 4: Judgment #2**

The NUT transmits an IKE_AUTH request including "ENCR_3DES", "AUTH_HMAC_SHA1_96" and "No Extended Sequence Numbers" as proposed algorithms. Configuration Payload is a Configuration Attribute. Its Attribute Type is INTERNAL_IP6_ADDRESS.

**Possible Problems:**

- If a device cannot discontinue support of IPv4 this test may be omitted.

********************************************************************************