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GROUP REPORT

6TiSCH Interoperability Test Specifications

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) IPv6 Integration (IP6).

Modal verbs terminology

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1 Scope

The present document aims to provide guidelines for performing 6TiSCH Conformance and Interoperability Tests. To this aim, it describes:

- The testbed architecture showing which IETF 6TiSCH systems and components are involved, and how they are going to inter-work in the interoperation focus.
- The configurations used during test sessions, including the relevant parameter values of the different layers (IEEE 802.15.4e TSCH and RPL).
- The interoperability test descriptions, describing the scenarios, which the participants will follow to perform the tests.
- The guidelines for participants on how to use the *golden device* to test against their implementation.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] IEEE 802.15.4e™: "IEEE Standard for Local and metropolitan area networks-- Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 1: MAC sublayer".

[i.2] IETF RFC 8180: "Minimal 6TiSCH Configuration", IETF 6TiSCH Working Group, X. Vilajosana, K. Pister. June 2015.

[i.3] IETF RFC 6550: "RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks", T. Winter, P. Thubert, A. Brandt, J. Hui, R. Kelsey, P. Levis, K. Pister, R. Struik, JP. Vasseur, and R. Alexander, March 2012.

[i.4] IETF RFC 6552: "Objective Function Zero for the Routing Protocol for Low-Power and Lossy Networks (RPL)", P. Thubert, March 2012.

[i.5] IETF RFC 6553: "The Routing Protocol for Low-Power and Lossy Networks (RPL) Option for Carrying RPL Information in Data-Plane Datagrams", J. Hui, and JP. Vasseur, March 2012.

[i.6] IETF RFC 6554: "An IPv6 Routing Header for Source Routes with the Routing Protocol for Low-Power and Lossy Networks (RPL)", J. Hui, JP. Vasseur, D. Culler, and V. Manral, March 2012.

[i.7] IETF RFC 4919: "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals", N. Kushalnagar, G. Montenegro, and C. Schumacher, August 2007.

[i.8] draft-ietf-6tisch-6top-protocol-09: "6TiSCH Operation Sublayer (6top)", IETF 6TiSCH Working Group, Qin Wang, Xavier Vilajosana, November 2015.

[i.9] draft-ietf-6lo-routing-dispatch-02: "6LoWPAN Routing Header And Paging Dispatches", IETF 6lo Working Group, P. Thubert, C. Bormann, L. Toutain, January 2016.

[i.10] IETF RFC 7554: "Using IEEE 802.15.4e Time-Slotted Channel Hopping (TSCH) in the Internet of Things (IoT): Problem Statement", T. Watteyne, M. R. Palattella, L. A. Grieco, May 2015.

[i.11] ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".

[i.12] ETSI EG 202 568: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Testing: Methodology and Framework".

[i.13] IETF RFC 6282: "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks".

[i.14] IETF RFC 6775: "Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)".

[i.15] draft-ietf-6tisch-6top-sf0-00: "6TiSCH 6top Scheduling Function Zero / Experimental (SFX)".

[i.16] draft-ietf-6tisch-6top-protocol-04: "6TiSCH Operation Sublayer (6top) Protocol (6P)".

[i.17] IEEE 802.15.4-2015™: "IEEE Standard for Low-Rate Wireless Networks".

[i.18] draft-ietf-6tisch-6top-protocol-01: "6top Protocol (6P)".

[i.19] draft-ietf-6tisch-minimal-security-03: "Minimal Security Framework for 6TiSCH".

[i.20] draft-ietf-6lo-backbone-router-01: "IPv6 Backbone Router".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

DAG root (DR): 6TiSCH Node acting as root of the DAG in the 6TiSCH network topology

6TiSCH Node (6N): any node within a 6TiSCH network other than the DAG root

NOTE: It may act as parent and/or child node within the DAG. It communicates with its children and it parent using the 6TiSCH minimal schedule, or any other TSCH schedule. In the test description, the term is used to refer to a non-DAG root node.

System Under Test (SUT): any composition of a number of Nodes Under Test implemented by different vendors

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACK ACKnowledgement packet
ARO Address Registration Option
BBR BackBone Router

BBR-ND	BackBone Router – Neighbor Discovery
DAC	Duplicate Address Confirmation
DAD	Duplicate Address Detection
DAG	Directed Acyclic Graph
DAO	RPL Destination Advertisement Object
DAR	Duplicate Address Request
DG	DaG root
DIO	RPL DAG Information Object
DODAG	Destination Oriented DAG
DR	Dag Root
EARO	Extended ARO
EB	Enhanced Beacon packet
F	Frequency
GD	Golden Device
GD/root	Golden Device acting as DAG root
GD/root/SEC	GD/root with enabled security options
GD/sniffer	Golden Device acting as PS
GPIO	General-Purpose Input/Output
IE	Information Element
IOC	InterOperation and Conformance
IOP	InterOPeration
IP	Internet Protocol
JP	Join Protocol
JRC	Join Registrar/Coordinator
KA	Keep-Alive message
LA	Logic Analyser
LBR	Low-Power and Lossy Network Border Router
MIC	Message Intergrity Check
MMCX	Micro-Miniature CoaXial
NA	Neighbor Advertissement
ND	Neighbor Discovery
NS	Neighbor Solicitation
NUT	Node Under Test
OSC	OSCilloscope
PAN	Personal Area Network
PANID	PAN IDentifier
PS	Packet Sniffer
RPI	RPL Packet Information
RPL	Routing Protocol for Low power and Lossy Networks
SEC	SECurity
SMA	SubMiniature version A
SUT	System Under Test
SYN	SYNchronization
TD	Test Description
TID	Transaction IDentifier
u.FL	micro Flex
UDP	User Datagram Protocol

4 User defined clause(s) from here onwards

4.1 User defined subdivisions of clause(s) from here onwards

4.1.1 Introduction

According to well-established test methodology, such as ETSI EG 202 237 [i.11] and ETSI EG 202 568 [i.12], it is possible to distinguish two different and complementary ways for testing devices which implement a given standard: Conformance and Interoperability testing.

Conformance Testing aims at checking whether a product correctly implements a particular standardized protocol. Thus, it establishes whether or not the protocol Implementation Under Test (IUT) meets the requirements specified for the protocol itself. For example, it will test protocol *message contents and format* as well as the *permitted sequences of messages*.

Interoperability Testing aims at checking whether a product works with other similar products. Thus, it proves that end-to-end functionality between (at least) two devices (from different vendors) is, as required by the standard(s) on which those devices are based.

Conformance testing in conjunction with interoperability testing provides both the proof of conformance and the guarantee of interoperation. ETSI EG 202 237 [i.11] and ETSI EG 202 568 [i.12] describe several approaches on how to combine these two methods. The most common approach consists in Interoperability Testing with Conformance Checks, where reference points between the devices under test are monitored to verify the appropriate sequence and contents of protocol messages, API calls, interface operations, etc. This will be the approach used by the 6TiSCH Plugtests.

The test session will be mainly executed between two devices from different vendors. For some test descriptions, it may be necessary to have more than two devices involved. The information about the test configuration, like the number of devices or the roles required are indicated in clause 6.

4.1.2 The test description pro forma

The test descriptions are provided in pro forma tables, which include the different Steps of the Test Sequence. The Steps may be of different types, depending on their purpose:

- A stimulus corresponds to an event that triggers a specific protocol action on a NUT, such as sending a message.
- A configure corresponds to an action to modify the NUT or SUT configuration.
- An IOP check (IOP stands for "Interoperation") consists of observing that one NUT behaves as described in the standard: i.e. resource creation, update, deletion, etc. For each IOP check in the Test Sequence, a result is recorded.
- The overall IOP Verdict will be considered PASS if all the IOP checks in the sequence are PASS.

In the context of *Interoperability Testing with Conformance Checks*, an additional step type, CON checks (CON stands for "Conformance") may be used to verify the appropriate sequence and contents of protocol messages, API calls, interface operations, etc.

In this case, the IOP Verdict will be PASS if all the IOP checks are PASS, and CON Verdict will be PASS if all the CON checks are PASS. The IOP/CON Verdict will be FAIL if at least one of the IOP/CON checks is FAIL.

Every IOP check and CON check of a test description should be performed using a trace created by a monitor tool, as described in clause 4.2.

4.2 Tooling

Participant may use their own tools for logging and analysing messages for the "check" purpose. The monitor tools include:

Packet Sniffer: An IEEE 802.15.4e compliant Packet Sniffer (PS) and the relevant tools to be able to analyse packets exchanges over the air. Participant will be free to use their own PS, or a GD/sniffer made available by the 6TiSCH Plug tests organizers.

Logic Analyser or Oscilloscope: A Logic Analyser (LA) to display the state of a GPIO (a pin on a board). Tools to convert the captured data into timing diagrams are necessary.

Debug Pins (GPIOs): To the scope of the tests, at least two programmable Digital I/O pins are recommended. One of the Debug pins should be used to track the slotted activity, and thus, be toggled at the beginning of each timeslot. The other debug pin should be toggled every time an action as defined by the timeslot template happens, i.e. the debug pin will toggle at tsTxOffset, tsRxAckDelay, etc.

Antenna Attenuators: The attenuators (which can be of different type: SMA, MMCX, u.FL) will be used to simulate distance between nodes. By doing so, multi-hop topologies can be constructed without the need of physically separating nodes. An attenuator can connect two motes using a *pigtail* (little wire) with the corresponding antenna connector (e.g. SMA, MMCX, u.FL, etc.). Several attenuators (10 dB, 20 dB, 30 dB, etc.) will be used. It is also preferable that they can be connected in a *daisy chain*.

4.3 Test Description naming convention

All the tests described in the present document, which will be performed during the Plugtests, can be classified in different groups, based on the type of features they verify. There are four different groups of tests: Synchronization (SYN), Packet Format (FORMAT), RPL features (RPL), and Security (SEC).

For each group, several tests are performed.

To identify each test, this TD uses a Test ID following the following naming convention:
TD_6TiSCH_<test group>_<test number within the group>.

4.4 6TiSCH Tests Summary

Table 1: 6TiSCH Tests

Test Number	Test ID	Test Summary	Test Group
1	TD_6TiSCH_SYN_01	Check that a 6N synchronizes and keeps synchronized by receiving EBs.	SYN
5	TD_6TiSCH_MINIMAL_01	Check the format of the IEEE 802.15.4e [i.1] EB packet is correctly assembled.	MINIMAL
6	TD_6TiSCH_MINIMAL_02	Check the timing template of TSCH time slot defined in IETF RFC 8180 [i.2] is correctly implemented.	MINIMAL
7	TD_6TiSCH_MINIMAL_03	Check channel hopping is correctly implemented according to IETF RFC 8180 [i.2].	MINIMAL
8	TD_6TiSCH_MINIMAL_04	Check the number of retransmissions is implemented following IETF RFC 8180 [i.2].	MINIMAL
9	TD_6TiSCH_MINIMAL_05	Check the minimal schedule is implemented according to IETF RFC 8180 [i.2].	MINIMAL
10	TD_6TiSCH_MINIMAL_06	Check the 6N sets its slot frame size correctly when joining the network.	MINIMAL
11	TD_6TiSCH_RPL_01	Check the value of EB join priority of a child 6N and a parent DR.	RPL
12	TD_6TiSCH_RPL_02	Check the rank of 6N is computed correctly according to IETF RFC 8180 [i.2].	RPL
13	TD_6TiSCH_RPL_03	Check a 6N child changes its time source neighbour (parent) correctly.	RPL
14	TD_6TiSCH_RPL_04	Check the format of RPL DIO message.	RPL
15	TD_6TiSCH_RPL_05	Check the format of RPL DAO message.	RPL
16	TD_6TiSCH_RPL_06	Check IP extension header in 6LoWPAN.	RPL
19	TD_6TiSCH_6P_01	Check that a 6N can ADD a cell in the schedule according to draft-ietf-6tisch-6top-protocol-09 [i.8].	6P
20	TD_6TiSCH_6P_02	Check that a 6N can COUNT the cells allocated in the schedule to a given neighbour, according to draft-ietf-6tisch-6top-protocol-09 [i.8].	6P
21	TD_6TiSCH_6P_03	Check that a 6N can obtain the LIST of cells in the schedule, according to draft-ietf-6tisch-6top-protocol-09.	6P
22	TD_6TiSCH_6P_04	Check that a 6N can CLEAR the schedule of a node, according to draft-ietf-6tisch-6top-protocol-09.	6P
23	TD_6TiSCH_6P_05	Check that a 6N can DELETE a cell in the schedule according to draft-ietf-6tisch-6top-protocol-09 [i.8].	6P
24	TD_6TiSCH_6P_06	Check the correct implementation of the 6P timeout (after a 6P request is received), according to draft-ietf-6tisch-6top-protocol-09 [i.8]	6P
25	TD_6TiSCH_6LoRH_01	Check that the source routing header is correctly encoded as a 6LoRH Critical RH3, according to draft-ietf-6lo-routing-dispatch-02 [i.9].	6LoRH

Test Number	Test ID	Test Summary	Test Group
26	TD_6TiSCH_6LoRH_02	Check that, when the packet's sent towards the DR, the RPL Information Option is correctly encoded as a 6LoRH RPI, according to draft-ietf-6lo-routing-dispatch-02 [i.9].	6LoRH
27	TD_6TiSCH_6LoRH_03	Check that, when the packet's travel inside the RPL domain, the IP in IP 6LoRH will not be presented in the packet.	6LoRH
28	TD_6TiSCH_6LoRH_04	Check that, when the packet travel outside a RPL domain, IP in IP 6LoRH is present in the packet.	6LoRH
29	TD_6TiSCH_SF0_01	Check SF0 initial overprovision of cells at bootstrap, according to draft-ietf-6tisch-6top-sf0-00 [i.15].	SF0
30	TD_6TiSCH_SF0_02	Check SF0 progressive allocation of cells as traffic demand increases, according to draft-ietf-6tisch-6top-sf0-00 [i.15].	SF0
31	TD_6TiSCH_SF0_03	Check SF0 progressive de-allocation of slots as traffic demand decreases, according to draft-ietf-6tisch-6top-sf0-00 [i.15].	SF0
32	TD_6TiSCH_SECJOIN_01	check that the join request is correctly received at the JRC.	SECJOIN
33	TD_6TiSCH_SECJOIN_02	check that the join response is correctly received at the Pledge.	SECJOIN
34	TD_6TiSCH_SECJOIN_03	check that JP correctly forwards (proxies) the Join Request to the JRC, on behalf of the Pledge.	SECJOIN
35	TD_6TiSCH_SECJOIN_04	check that the join response is correctly received at the Pledge (after having been proxied by the JP).	SECJOIN
36	TD_6TiSCH_SECJOIN_05	Resistance to alteration of requests.	SECJOIN
37	TD_6TiSCH_SECJOIN_06	Resistance to replay of requests.	SECJOIN
38	TD_6TiSCH_SECJOIN_07	Resistance to eavesdropping.	SECJOIN
39	TD_6TiSCH_SECJOIN_08	Detection of flaws in the authentication.	SECJOIN
40	TD_6TISCH_BBR-ND_01	Check registration of nodes to BBR based on ND.	BBR-ND
41	TD_6TISCH_BBR-ND_02	Check registration of nodes to BBR based on RPL.	BBR-ND
42	TD_6TISCH_BBR-ND_03	Check de-registration of nodes to the Backbone router.	BBR-ND
43	TD_6TISCH_BBR-ND_04	Check that a node can move to another backbone router while still keeping the registration.	BBR-ND
44	TD_6TISCH_BBR-ND_05	Check that a collision is detected when a node registers to the backbone with an already registered EUI64.	BBR-ND

5 6TiSCH Test Configurations

5.1 Node Under Test (NUT)

In the context of 6TiSCH, and according to IETF RFC 8180 [i.2], a Node Under Test is a low-power wireless node equipped with a IEEE 802.15.4-compliant radio, and implementing **at least:**

- the IEEE 802.15.4e [i.1] TSCH MAC protocol
- the RPL routing protocol [i.3]
- the 6LoWPAN adaptation layer [i.7]

In the scope of this Test Description, a NUT also implements:

- draft-ietf-6tisch-6top-protocol-09 [i.8]
- draft-ietf-6lo-routing-dispatch-02 [i.9]
- the UDP protocol

When executing the tests described in the present document, the relevant parameter values of the protocols adopted at different layers (IEEE 802.15.4e TSCH and RPL) are set according to [i.2], [i.8] and [i.9]. Those not defined in [i.2], [i.8] and [i.9] are specified in this TD.

Additionally, the NUT needs to implement specific functions not defined in the draft or standard but necessary for conducting the tests. In the scope of this Test Description, a NUT also implements:

- A way to issue a 6P Request.
- A way to disable and enable 6P Response.

Issuing a 6P Request can be triggered either by pressing a button event or by serial command input. There is no specific requirement for how to implement this function as long as the node support that. The disabling and enabling 6P Response functions are required when conducting the timeout test (TD_6TiSCH_6P_06). "Disable the 6P Response" means the node do not send response even it is available to send. This makes node stuck at the current 6P transaction. Then "Enable the 6P Responses" operation makes the node back to normal. However, the node only able to send the response after TIMEOUT.

5.2 System under Test (SUT)

5.2.1 Single-hop scenario

For most tests, the SUT will be a 6TiSCH single-hop topology, including a DAG root and a 6TiSCH Node. The DR will be implemented with a golden device (GD/root or GD/root/SEC), or a vendor node based on the type of test performed (conformance and interoperability tests, respectively). For some tests, in order to check specific features (e.g. packet format, minimal schedule), a packet sniffer will be also needed, in order to listen to the packets on the air, exchanged between the DR and the 6N. Each vendor will be free to use its own PS, or a golden device acting as PS (GD/sniffer) will be provided.

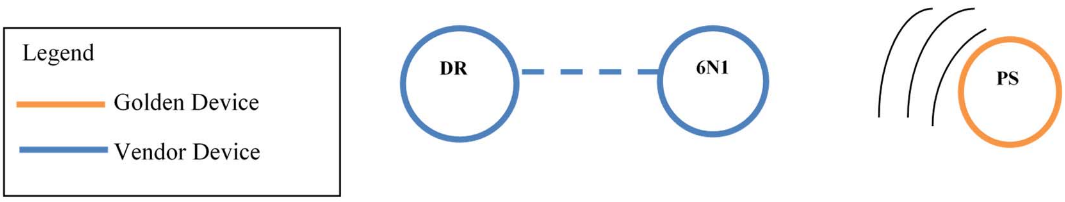

Figure 1: Single-hop scenario

5.2.2 Multi-hop_1 scenario

The multi-hop scenario includes a DAG root and two 6TiSCH Nodes, connected as displayed in Figure 2, in a linear topology. The DR will be either a GD/root (or GD/root/SEC) or a vendor node. For some tests, another GD/sniffer or a vendor PS will be used for capturing the packets exchanged in the multi-hop network.

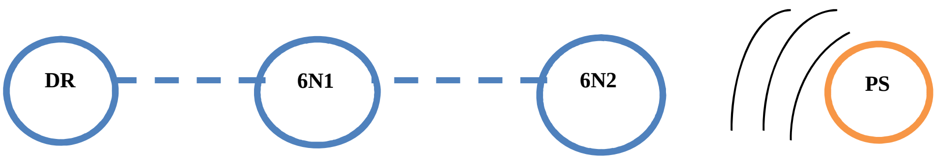

Figure 2: Multi-hop scenario

Moreover, in order to check if a 6N child can change its time source neighbour (parent) correctly (test #13) the multi-hop scenario will be extended, by including another 6N in the network.

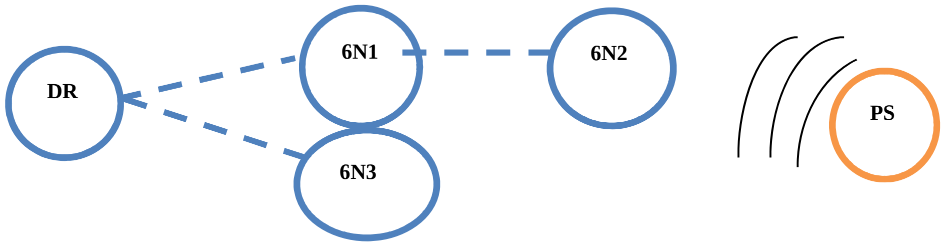

Figure 3: Multi-hop scenario with three 6N (and 6N2 changing parent node)

5.2.3 Multi-hop_2 scenario

The multi-hop scenario includes 1 DR and three 6Ns, forming a linear topology as displayed in Figure 4. 6LoRH features use this topology for testing. The DR is either a GD/root or a vendor node. For some tests, another GD/sniffer or a vendor PS is used for capturing the frames exchanged.

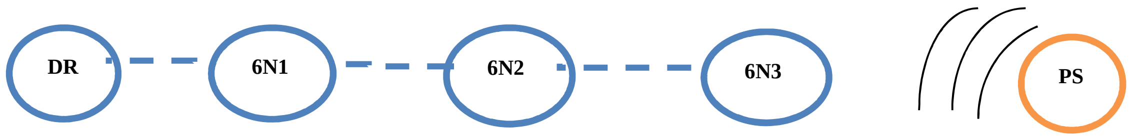

Figure 4: Multi-hop_2 scenario

5.2.4 Star scenario

The star scenario includes 1 DR and two 6Ns, both directly connected to the DR, as displayed in Figure 5. For some tests, another GD/sniffer or a vendor PS is used for capturing the frames exchanged.

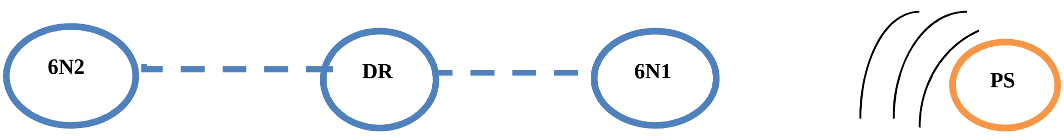

Figure 5: Star scenario

5.3 Golden Device

5.3.1 Introduction

This clause describes the three images which will be implemented on the Golden Device to perform the different tests listed in clause 6. With the first two images, the GD will act as DAG root with security option disabled (GD/root), or enabled (GD/root/SEC). While with the last image, the GD will act as packet sniffer (GD/sniffer). All the images can be configured using a script (described in clause 5.3.4), which allows setting the value of several parameters (e.g. frequency, slot frame size, etc.), or triggering the transmission of a given type of packet (EB, DATA, ACK, etc.). The commands which allow configuring the images are presented in clause 5.3.3, while the specific set of parameters to be used for each test, are specified in clause 6.

5.3.2 GD/root

With this first image the golden device works as DAG root. By using the script, it is possible to configure: the number of frequencies (Single frequency or Multiple Frequencies/Channel Hopping), the slot frame size, the type of packet to send/receive (EB, KA, DATA, ACK, DIO and DAO), and the value of the DAG rank. Moreover, by using the script, the GD/root can print out several information, related to the packet that it received from the vendor node. For example, following the reception of a KA message, the GD/root can print out the information about the ASN when the KA was received, and the Time Offset of the vendor node.

The details about how to use the GD/root for each specific test are provided in clause 6.

5.3.3 GD/root/SEC

With this second image, the golden device still works as DAG root but with security features (authentication, and data encryption) enabled. This image can be configured using the same set of command specified for GD/root.

5.3.4 GD/sniffer

With this third image, the golden device works as a packet sniffer which listens to packets on the air. By using the script, it is possible to configure the specific frequency the GD/sniffer is listening on. The packet sniffer knows the correct format of the different types of packets. When capturing a packet, the GD/sniffer can provide several information about the type of packet (EB, KA, DATA, DIO, and DAO), its source address, its destination address, the ASN, the channel hopping sequence (identified by a template ID), the timeslot template, etc. All the information are displayed on the screen of a laptop connected to the GD/sniffer.

Conformance tests use the GD/sniffer to check the packet format and specific values of some fields of the packets sent by vendor nodes.

5.3.5 Configuring Script

This clause introduces the python script which allows configuring the three images of the golden device. In detail, it describes the set (and format) of commands used for setting up the value of specific parameters, in order to obtain different configurations of the golden device.

The format of each command is displayed in Table 2.

Table 2: Format of Script Command

Length (bytes)	**1**	**1**	**Variable**
Script Command Content	Version	Image ID	Command Content

Version: the first field of the command (1 byte long) indicates the version of script. The command is valid only when its version matches the one supported by the GD image. Otherwise, the command is discarded by the GD.

Image ID: the second field of the command (1 byte long) indicates the Image ID. When it is set to 1, the GD will run GD/root, when it is set to 2, it will run GD/root/SEC and finally, when it is set to 3, it will run GD/sniffer. If the value of Image ID in the command sent to the GD is different from the three allowed values (1 and 2), the command is discarded by the GD.

Command Content: this field (variable length) is composed by three different fields, as specified in Table 3.

Table 3: Format of Command Content

Length (bytes)	**1**	**1**	**Variable**
Command Content	Command ID	Length	(value of) Parameter

Command ID: this field (1 byte long), together with Image ID allows identifying the specific command used for configuring the GD.

Length: this field (1 byte long) specifies the length of the next field, i.e. of the parameter content.

(value of) Parameter: this field contains the value of the specific parameter configured by using that command. Table 4 summarizes the list of parameters that can be configured, using different commands (identified by different Command ID).

Table 4: List of Commands

Command Scope	Command ID	length	Parameter	Allowed Range of Value	Unit
Send EB	0	2 bytes	Sending period	0~65 535	second
Configure Frequency	1	1 byte	Frequency number	(0,11~26, when frequency number is set to 0, channel hopping is enabled)	
Send KA	2	2 bytes	Sending period	0~65 535	millisecond
Send DIO	3	2 bytes	Sending period	0~65 535	millisecond
Send DAO	4	2 bytes	Sending period	0~65 535	millisecond
Set Rank Value	5	2 bytes	Rank	0~65 535	
Enable/Disable Security	6	1 byte	Option	True(enable) False(disable)	
Set Slot frame Size	7	2 bytes	Slot frame length	0~65 535	
Enable/Disable ACK Transmission	8	1 byte	Option	True(enable) False(disable)	
Issue a 6P ADD Packet	9	Multiple bytes (0 to 3)	Candidate cell List	0~slotframeLength-1 (for each cell in list)	
Issue a 6P DELETE Packet	10	Multiple bytes (0 to 3)	Candidate cell List	0~slotframeLength-1 (for each cell in list)	
Issue a 6P COUNT Packet	11	0	None	None	
Issue a 6P LIST Packet	12	0	None	None	
Issue a 6P CLEAR Packet	13	0	None	None	
Set Slot Duration	14	2 bytes	Duration	0~65 535	Ticks (30,5 us)
Enable/Disable 6P Response	15	1 byte	Option	True(enable) False(disable)	

Any other value of Command ID not listed in Table 4 is treated as an error, and the command is discarded by the GD.

Beyond setting the set of parameters, listed in Table 4, the script when used with GD/root allows printing out on the screen of the laptop connected to GD/root, the received packet, and all the related information (type of packet, ASN when the packet is received, time offset, 6P return code, number of reserved cell, cell list etc.); and when used with GD/sniffer, it allows parsing the captured packet. The format of the packet is printed out on the screen of the laptop connected to GD/sniffer to verify the correctness of the packet format itself.

Vendors are free to bring their own packet sniffer, able to support similar functions to those of GD/sniffer in order to perform both interoperability and conformance tests.

6 Test Descriptions

6.1 Synchronization

Test 1 -TD_6TiSCH_SYN_01

Test Number	1			
Test ID	TD_6TiSCH_SYN_01			
Test Objective	Check that a 6N synchronizes and keeps synchronized by receiving EBs			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer or a vendor PS can be used.			
References	IEEE 802.15.4-2015 [i.17]			
Pre-test conditions	DAG root and 6N are turned off you have a sniffer continuously listening on the frequency all devices are communicating on			
Test sequence	Step	Type	Description	Result
	1	Stimulus	Switch on DAG root Switch on 6N	
	2	IOP Check	The 6N synchronizes after having received an EB	
	3	IOP Check	The 6N keeps synchronized for at least 100 sec. How this is done is implementation specific, e.g. verify an LED stays on	
	4	IOP Check	During that period, the 6N does NOT send KA frames	
IOP Verdict				

Test 2 -TD_6TiSCH_SYN_02

Test Number	2			
Test ID	TD_6TiSCH_SYN_02			
Test Objective	Check a 6N can synchronize to DR with KA			
Configuration	Single hop			
Applicability	SUT includes a PS to see the EB and KA on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1]			
Pre-test conditions	The DR sends EBs periodically with a rate equal to 10 sec [i.2]. The 6N is synchronized to DR with EB. The 6N sends KA periodically, every 1 sec. All EB and KA packets are sent on a single frequency. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N sends the KA message	
	2	IOP Check	The DR receives the KA	
IOP Verdict				

Test 3 -TD_6TiSCH_SYN_03

Test Number	3			
Test ID	TD_6TiSCH_SYN_03			
Test Objective	Check a 6N clock drifts if there is no re-synchronization.			
Configuration	Single hop			
Applicability	SUT includes a PS to see the EB and KA on the air. To this purpose, GD/sniffer-IM2, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1]			
Pre-test conditions	The DG sends only one EB (to this purpose the EB period will be set to the max value, equal to 255 sec). All EB and KA packets are sent on a single frequency. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends one EB	
	2	IOP Check	The 6N sends KA	
	3	Configure	The DR does not ACK the KA	
	4	Configure	The 6N sends KA again	
	5	IOP Check	The DR ACK the reception of the KA, and time correction for re-synch is specified in the ACK	
IOP Verdict				

Test 4 -TD_6TiSCH_SYN_04

Test Number	4			
Test ID	TD_6TiSCH_SYN_04			
Test Objective	Check the 6N can recover synchronization after de-synchronization.			
Configuration	Single hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends EB.	
	2	IOP Check	The 6N synchronizes with the DR. Then, it sends EBs, and KAs for keeping synchronization (which will be printed out by GD/root).	
	3	Configure	Power off the DR.	
	4	IOP Check	The 6N loses synchronization, and thus it stops sending both EBs and KAs. The PS will not capture any message.	
	5	Configure	Power on the DR.	
	6	IOP Check	The 6N synchronizes again with the DR, and start sending again EBs and KAs. The DR will receive KA sent by the 6N.	
IOP Verdict				

6.2 Minimal tests

Test 5 -TD_6TiSCH_MINIMAL_01

Test Number	5			
Test ID	TD_6TiSCH_MINIMAL_01			
Test Objective	Check the format of the IEEE 802.15.4e [i.1] EB packet is correct.			
Configuration	Single hop (1DR, and a GD/sniffer) 6N is not needed for this test			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], IETF RFC 8180 [i.2]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Turn on the sniffer at SYN F.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DG sends an EB	
	2	IOP Check	The PS capture the EB	
	3	IOC Check	Check the packet header captured by the sniffer has the same format defined in the IEEE 802.15.4e [i.1]	
	4	IOC Check	Check the sync IE captured by the sniffer has the same format defined in IETF RFC 8180 [i.2]	
	5	IOC Check	Check the timeslot Template IE captured by the sniffer has the same format defined in IETF RFC 8180 [i.2]	
	6	IOC Check	Check the Channel Hopping IE captured by the sniffer has the same format defined in IETF RFC 8180 [i.2]	
	7	IOC Check	Check the frame & link IE captured by the sniffer has the same format defined in IETF RFC 8180 [i.2]	
IOP Verdict				

Test 6 -TD_6TiSCH_MINIMAL_02

Test Number	6			
Test ID	TD_6TiSCH_MINIMAL_02			
Test Objective	Check the timing template of TSCH time slot defined in IETF RFC 8180 [i.2] is correctly implemented			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB and ping messages on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	DR sends only one EB for allowing synchronization of 6N. If DR is able to ping 6N (thus, they exchange Echo Request and Echo Reply), it means they are using the same timing template. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends an Echo Request DATA message	
	2	IOP Check	The 6N sends an Echo Reply ACK message	
	3	IOP Check	The DR correctly receives the Echo Reply message	
IOP Verdict				

Test 7 -TD_6TiSCH_MINIMAL_03

Test Number	7			
Test ID	TD_6TiSCH_MINIMAL_03			
Test Objective	Check the channel hopping on frequency is correctly implemented (i.e. the 6N sends DATA packets on different channels in consecutive slot frames)			
Configuration	Single-hop			
Applicability	SUT includes a GD/sniffer or a vendor PS switching across the 16 frequencies			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	Number of available frequencies is set to 16. Only one slot (corresponding to slot Offset 0) is scheduled for sending and receiving DATA packets. Per each slot frame, the sniffer is listening on a different frequency, calculated according to the channel sequence defined in IETF RFC 8180 [i.2].			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N sends a data packet through slot 0	
	2	IOP Check	The PS captures the packet as expected	
	3	Configure	Change the channel the PS is listening on, according the channel hopping sequence in IETF RFC 8180 [i.2]. Wait until the next slot frame, when the channel hopping will happen.	
	4	IOP Check	Check the PS capture the DATA packet on the channel when the hopping happened.	
	5	IOP Check	Repeat step 3 and step 4, for all the other 14 frequencies.	
IOP Verdict				

Test 8 -TD_6TiSCH_MINIMAL_04

Test Number	8			
Test ID	TD_6TiSCH_MINIMAL_04			
Test Objective	Check the retransmissions time is 3 as defined in IETF RFC 8180 [i.2]			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB and KA on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	DR sends EB periodically, every 10 sec as per [i.2]. 6N is synchronized to DG (according to TD_6TiSCH_SYN_01). The DR is configured to not send ACK back to 6N after receiving packets from 6N. All frames are sent on a single frequency.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N sends a KA packet to the DR	
	2	IOP Check	The PS captures the KA packet	
	3	IOP Check	No ACK packet is captured by the PS	
	4	IOP Check	3 more KA packets are captured by the PS and all of them without ACK response	
IOP Verdict				

Test 9 -TD_6TiSCH_MINIMAL_05

Test Number	9			
Identifier	TD_6TiSCH_MINIMAL_05			
Test Objective	Check the minimal schedule (with slot frame size equal to 11 slots, and 1 single scheduled cell) is correctly implemented according to IETF RFC 8180 [i.2]			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	DR sends EB periodically, every 10 sec as per [i.2]. 6N is synchronized to DG (according to TD_6TiSCH_SYN_01). Power on DR and 6N.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR send an EB	
	2	IOP Check	The 6N after getting synchronized, sends an EB	
	3	IOC Check	Check the minimal schedule is well implemented, by checking the value of the IEs in the EB sent by 6N	
IOP Verdict				

Test 10 -TD_6TiSCH_MINIMAL_06

Test Number	10			
Test ID	TD_6TiSCH_MINIMAL_06			
Test Objective	Check a 6N sets its slot frame length correctly when joining the network (according to information in EB packet and link IE)			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	Set slot frame size of DR equal to 11 Power on 6N and DR			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends an EB	
	2	IOP Check	The 6N get synchronized, and sends an EB	
	3	IOP Check	The slot frame size in the EB sent by the 6N and captured by the PS has the same value of the slot frame size of the EB sent by the DR	
	4	Configure	Set slot frame size of DR equal to 7	
	5	IOP Check	The DR sends a new EB announcing the new slot frame size (equal to 7)	
	6	IOP Check	Wait till 6N get synchronized again with DR, and check the EB sent by 6N is announcing slot frame size equal to 7	
IOP Verdict				

6.3 RPL features

Test 11 -TD_6TiSCH_RPL_01

Test Number	11			
Test ID	TD_6TiSCH_RPL_01			
Test Objective	Check the value of EB join priority of child 6N and a parent DR			
Configuration	Single-hop			
References	RPL			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
Pre-test conditions	The DG sends only one EB. The 6N sends only one EB. Only the SYN F is used for transmitting and receiving EB. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends an EB	
	2	IOP Check	Wait till the 6N has acquired a RPL rank and sends an EB back (which will be captured by the PS)	
	3	IOP Check	Check the EB priority of the 6N is set to the rank/256	
IOP Verdict				

Test 12 -TD_6TiSCH_RPL_02

Test Number	12			
Test ID	TD_6TiSCH_RPL_02			
Test Objective	Check the rank of 6Ns is computed correctly, according to OF0 function, as specified in IETF RFC 8180 [i.2]			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	EB is sent periodically, every 10 sec. DIO is sent periodically.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR send an EB	
	2	IOP Check	6N1 and 6N3 synch with DR as per TD_6TiSCH_SYN_01	
	3	IOP Check	6N1 and 6N3 send EB	
	4	IOP Check	6N2 pick one of the other 6N as its parent (time source) node, forming a 2-hop topology	
	5	IOP Check	6Ns sends DIOs periodically	
	6	IOP check	Check the ranks in the DIO messages of 6Ns is computed correctly, according to OF0 function	
IOP Verdict				

Test 13 -TD_6TiSCH_RPL_03

Test Number	13			
Test ID	TD_6TiSCH_RPL_03			
Test Objective	Check a 6N changes its time source (parent) node correctly (i.e. when the difference between the rank of new candidate neighbour and current neighbour is greater than PARENT_SWITCH_THRESHOLD = 394)			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	EB are sent periodically, every 10 sec. DIO are sent periodically.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The rank of 6N1 is larger of the rank of 6N3, but the difference between the ranks is lower than PARENT_SWITCH_THRESHOLD	
	2	IOP Check	6N2 has still 6N1 as its time source neighbour	
	3	Configure	Move 6N1 far from 6N2	
	4	IOP Check	The rank of 6N3 is larger than the rank of 6N1, greater than PARENT_SWITCH_THRESHOLD	
	5	IOP Check	6N2 changes its time source to 6N3	
IOP Verdict				

Test 14 -TD_6TiSCH_RPL_04

Test Number	14			
Test ID	TD_6TiSCH_RPL_04			
Test Objective	Check the format of DIO message			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2], IETF RFC 6550 [i.3]			
Pre-test conditions	The DR and the 6N are synchronized			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DG sends DIO	
	2	IOP Check	The PS captures the DIO	
	3	IOC Check	Check the DIO shown on the PS has the same format defined in IETF RFC 6550 [i.3], section 6.3.1	
IOP Verdict				

Test 15 -TD_6TiSCH_RPL_05

Test Number	15			
Test ID	TD_6TiSCH_RPL_05			
Test Objective	Check the format of DAO message			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2], IETF RFC 6550 [i.3]			
Pre-test conditions	The DR and the 6Ns are synchronized			
Test sequence	Step	Type	Description	Result
	1	Stimulus	6N2 sends DAO	
	2	IOP Check	The PS captures the DAO	
	3	IOC Check	Check the DAO shown on the PS has the same format defined in IETF RFC 6550 [i.3], section 6.4.1	
IOP Verdict				

Test 16 -TD_6TiSCH_RPL_06

Test Number	16			
Test ID	TD_6TiSCH_RPL_06			
Test Objective	Check IP extension header in 6LoWPAN			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 6553 [i.5], IETF RFC 6554 [i.6], IETF RFC 6282 [i.13]			
Pre-test conditions	The DR and the 6N are synchronized. Both 6Ns send DAO messages.			
Test sequence	1	Stimulus	6N1 and 6N2 send DAO messages	
	2	IOP Check	DR receives DAO messages	
	3	Configure	DR sends a ping to 6N2	
	4	IOP Check	Check 6N1 is forwarding DR Echo Request packet to 6N2, according to IETF RFC 6554 [i.6] and IETF RFC 6282 [i.13].	
	5	IOP Check	Check 6N2 is forwarding 6N2 Echo Reply packet to DR, according to IETF RFC 6553 [i.5] and IETF RFC 6282 [i.13].	
IOP Verdict				

6.4 L2SEC

Test 17 -TD_6TiSCH_L2SEC_01

Test Number	17			
Test ID	TD_6TiSCH_L2SEC_01			
Test Objective	Check the 6N is correctly authenticated with K1, when it synchronizes to DR with EB			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB on the air. To this purpose, GD/sniffer or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to [i.2]), so that the 6N does not need to send KAs for keeping synchronization. The 6N needs to listen to one EB only. All frames are sent on a single frequency. **The SEC option is enabled on DR and 6N** The key K1 is set according to IETF RFC 8180 [i.2] Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The DR sends EB	
	2	IOP Check	The 6N receives the EB and get synchronized	
	3	IOP Check	The 6N sends EB	
	4	IOP Check	The DR receives the EB from 6N	
IOP Verdict				

Test 18 -TD_6TiSCH_L2SEC_02

Test Number	18			
Test ID	TD_6TiSCH_L2SEC_02			
Test Objective	Check the data packet sent by 6N is correctly encrypted with K2.			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the EB and DATA packet on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IETF RFC 8180 [i.2]			
Pre-test conditions	All frames are sent on a single frequency. **The SEC option is enabled on DR and 6N.** The key K1 and the key K2 are set according to IETF RFC 8180 [i.2] and clause 7 of the TD. Power on 6N and DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	DR sends a ping DATA packet to 6N	
	2	IOP Check	6N sends an Echo Reply message to DR	
	3	IOP Check	Check the DATA is correctly encrypted/decrypted with K2	
IOP Verdict				

6.5 6top Protocol (6P)

Test 19 -TD_6TiSCH_6P_01

Test Number	19			
Test ID	TD_6TiSCH_6P_01			
Test Objective	Check a 6N can ADD a cell in the schedule according to draft-ietf-6tisch-6top-protocol-09			
Configuration	Star			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DR sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until both 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P ADD request to the DR for 1 slot. The candidate list is {4,5}	
	2	IOP Check	The PS captures the sequence of request and response	
	3	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-protocol-09 for both the request and the response	
	4	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
	5	Stimulus	The 6N2 sends a 6P ADD request to the DR for 1 slot. The candidate list is {4}	
	6	IOP Check	The PS captures the sequence of request and response	
	7	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_RESET	
IOP Verdict				

Test 20 -TD_6TiSCH_6P_02

Test Number	20			
Test ID	TD_6TiSCH_6P_02			
Test Objective	Check a 6N can COUNT the cells allocated in the schedule to a given neighbour, according to draft-ietf-6tisch-6top-protocol-09.			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until the 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P ADD request to the DR for 1 slot. The candidate list is {4, 5}	
	2	Stimulus	The 6N1 sends a 6P COUNT request to the DR.	
	3	IOP Check	The PS captures the sequence of request and response	
	4	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-sublayer-04 for both the request and the response	
	5	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS. And the counter value received is 1	
IOP Verdict				

Test 21 -TD_6TiSCH_6P_03

Test Number	21			
Test ID	TD_6TiSCH_6P_03			
Test Objective	Check a 6N can obtain the LIST of cells in the schedule, according to draft-ietf-6tisch-6top-protocol-09.			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until the 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P ADD request to the DR for 2 slots. The candidate list is {4, 5}	
	2	Stimulus	The 6N1 sends a 6P LIST request to the DR	
	3	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS and the counter value received is 2	
	4	Stimulus	The 6N1 sends a 6P CLEAR request to the DR	
	5	IOP Check	The PS captures the sequence of request and response	
	7	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-protocol-09 for both the request and the response	
	8	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
	9	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
		IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS and the counter value received is 0	
IOP Verdict				

Test 22 -TD_6TiSCH_6P_04

Test Number	22			
Test ID	TD_6TiSCH_6P_04			
Test Objective	Check a 6N can CLEAR the schedule of a node, according to draft-ietf-6tisch-6top-protocol-09 [i.8].			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until the 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P ADD request to the DR for 2 slots. The candidate list is {4, 5}	
	2	Stimulus	The 6N1 sends a 6P COUNT request to the DR.	
	3	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS and the counter value received is 2	
	4	Stimulus	The 6N1 sends a 6P CLEAR request to the DR.	
	5	IOP Check	The PS captures the sequence of request and response	
	7	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-protocol-09 for both the request and the response	
	8	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
	9	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
	10	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS and the counter value received is 0	
IOP Verdict				

Test 23 -TD_6TiSCH_6P_05

Test Number	23			
Test ID	TD_6TiSCH_6P_05			
Test Objective	Check a 6N can DELETE a cell in the schedule according to draft-ietf-6tisch-6top-protocol-09 [i.8]			
Configuration	Star			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DR sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until both 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P ADD request to the DR for 1 slot. The candidate list is {4}	
	2	Stimulus	The 6N1 sends a 6P DELETE request to the DR for 1 slot. The candidate list is {4}	
	3	IOP Check	The PS captures the sequence of request and response	
	4	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-protocol-09 for both the request and the response	
	5	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
	6	Stimulus	The 6N2 sends a 6P DELETE request to the DR for 1 slot. The candidate list is {4}	
	7	IOP Check	The PS captures the sequence of request and response	
	8	IOC Check	Check the packet header captured by the sniffer has the same format defined in the draft-ietf-6tisch-6top-protocol-09 for both the request and the response	
	9	IOC Check	Check that the returned code for the operation is IANA_6TOP_RC_RESET	
IOP Verdict				

Test 24 -TD_6TiSCH_6P_06

Test Number	24			
Test ID	TD_6TiSCH_6P_06			
Test Objective	Check the timeout after a 6P request, is implemented according to draft-ietf-6tisch-6top-protocol-09.			
Configuration	Single-hop			
Applicability	SUT includes a PS to see the 6P packets on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-protocol-09 [i.8]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until the 6N joins the DR. Disable the 6P Response of DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
	2	IOP Check	No Response capture from PS	
	3	Stimulus	Enable the 6P Response of DR	
	4	Stimulus	The 6N1 sends a 6P ADD request to the DR for 2 slots. The candidate list is {4, 5} within TIMEOUT	
	5	IOP Check	The PS captures the sequence of request and response	
	6	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_ERR	
	7	Stimulus	The 6N-1 sends a 6P ADD request to the DR for 2 slots. The candidate list is {4, 5} after TIMEOUT	
	8	IOP Check	The PS captures the sequence of Request and Response	
	9	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
IOP Verdict				

6.6 6LoRH

Test 25 -TD_6TiSCH_6LoRH_01

Test Number	25			
Test ID	TD_6TiSCH_6LoRH_01			
Test Objective	Check that the source routing header is correctly encoded as a 6LoRH Critical RH3, according to draft-ietf-6lo-routing-dispatch-02			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the RH3 headers on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	draft-ietf-6lo-routing-dispatch-02 [i.8]			
Pre-test conditions	The DR sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until all the 6N join the network.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	Send an ICMPv6(echo request) packet to 6N3 (with source address inside of RPL domain)	
	2	IOP Check	The ICMPv6 receives the echo request	
	3	IOP Check	The PS captures the sequence of packets forwarded downstream to the 6N3	
	4	IOP Check	Check the 6LoRH RH3 header at each hop is compliant with draft-ietf-6lo-routing-dispatch-02	
IOP Verdict				

Test 26 -TD_6TiSCH_6LoRH_02

Test Number	26			
Test ID	TD_6TiSCH_6LoRH_02			
Test Objective	Check that, when the packet's sent towards the DR, the RPL Information Option is correctly encoded as a 6LoRH RPI, according to draft-ietf-6lo-routing-dispatch-02			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the RPI headers on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	draft-ietf-6lo-routing-dispatch-02 [i.8]			
Pre-test conditions	The DR sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. The DR sends DIO periodically, every 10 seconds. Power on DR. Wait until all the 6N join the network.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	sends The 6N3 sends a DAO packet	
	2	IOP Check	The PS captures the sequence of packet forwarded upstream to the DR	
	3	IOP Check	Check the 6LoRH RPI header at each hop is compressed and compliant with draft-ietf-6lo-routing-dispatch-02	
IOP Verdict				

Test 27 -TD_6TiSCH_6LoRH_03

Test Number	27			
Test ID	TD_6TiSCH_6LoRH_03			
Test Objective	Check that, when the packet's travel inside the RPL domain, the IP in IP 6LoRH is not be presented in the packet.			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the RPI headers on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	draft-ietf-6lo-routing-dispatch-02 [i.8]			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until all the 6N join the network.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	Send an echo request with source address inside of RPL domain and destination address of 6N3	
	2	IOP Check	6N3 received the echo request and send back echo response upstream to the DR	
	3	IOP Check	The PS captures the sequence of packet forwarded downstream to the 6N 3 and upstream to the DR	
	4	IOP Check	Check the 6LoRH RPI header at each hop is compressed and compliant with draft-ietf-6lo-routing-dispatch-02 and no IP in IP 6LoRH present in the packet	
IOP Verdict				

Test 28 -TD_6TiSCH_6LoRH_04

Test Number	28			
Test ID	TD_6TiSCH_6LoRH_04			
Test Objective	Check that, when the packet travel outside a RPL domain, IP in IP 6LoRH is present in the packet.			
Configuration	Multi-hop			
Applicability	SUT includes a PS to see the RPI headers on the air. To this purpose, GD/sniffer, or a vendor PS can be used.			
References	draft-ietf-6lo-routing-dispatch-02			
Pre-test conditions	The DG sends EB periodically, every 10 sec [i.2]. All EB packets are sent on a single frequency. Power on DR. Wait until all the 6N join the network.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	Send an echo request with source address outside of RPL domain and destination address of 6N3	
	2	IOP Check	6N3 received the echo request and send back echo response upstream to the DR	
	3	IOP Check	The PS captures the sequence of packet forwarded downstream to the 6N3 and upstream to the DR	
	4	IOP Check	Check the 6LoRH RPI header at each hop is compressed and compliant with draft-ietf-6lo-routing-dispatch-02 and IP in IP 6LoRH are presented in the packet	
IOP Verdict				

6.7 SF0

Test 29 -TD_6TiSCH_SF0_01

Test Number	29			
Test ID	TD_6TiSCH_SF0_01			
Test Objective	Check SF0 initial overprovision of cells at bootstrap, according to draft-ietf-6tisch-6top-sf0-00			
Configuration	single-hop			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-sf0-00 [i.15], draft-ietf-6tisch-6top-protocol-04 [i.16]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. All EB packets are sent on a single frequency. SF0THRESH is set to 3. Power on DR. Wait until 6N join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	SF0 is enabled on 6N1	
	2	IOP Check	The 6N1 sends a 6P ADD request to the DR for 1 slot. (at initial, schedule cells equals to require cells, add one slot)	
	3	IOP Check	The PS captures the sequence of request and response	
	4	IOP Check	Check the packet header captured by the sniffer has the same format defined in the Result draft-ietf-6tisch-6top-protocol-01 for both the request and the response	
	5	IOP Check	Check that the returned code for the operation is IANA_6TOP_RC_SUCCESS	
	6	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
	7	IOP Check	Check the counter value received is 1	
IOP Verdict				

Test 30 -TD_6TiSCH_SF0_02

Test Number	30			
Test ID	TD_6TiSCH_SF0_02			
Test Objective	Check SF0 progressive allocation of cells as traffic demand increases, according to draft-ietf-6tisch-6top-sf0-00			
Configuration	single-hop			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-sf0-00 [i.15], draft-ietf-6tisch-6top-protocol-01 [i.18]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. Nodes sends EB packets on a single frequency. SF0THRESH is set to 3. Power on DR. Wait until 6N1 join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	SF0 is enabled on 6N1	
	2	Stimulus	Increase traffic generating by 6N1 to 3 packet per slot frame	
	3	IOP Check	Check 6N1 sends a 6P ADD request to the DR, asking for a number of cells equal to 3	
	4	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
	5	IOP Check	Check the counter value received is 4	
IOP Verdict				

Test 31 -TD_6TiSCH_SF0_03

Test Number	31			
Test ID	TD_6TiSCH_SF0_03			
Test Objective	Check SF0 progressive de-allocation of slots as traffic demand decreases, according to draft-ietf-6tisch-6top-sf0-00			
Configuration	single-hop			
References	IEEE 802.15.4e [i.1], draft-ietf-6tisch-6top-sf0-00 [i.15], draft-ietf-6tisch-6top-protocol-01 [i.18]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. Nodes sends EB packets on a single frequency. SF0THRESH is set to 3. Power on DR. Wait until both 6N1 join the DR.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	SF0 is enabled on 6N1	
	2	Stimulus	Decrease traffic generating by 6N1 to 2 packet per slot frame	
	3	IOP Check	The 6N1 sends a 6P COUNT request to the DR	
	4	IOP Check	Check the counter value received is still 4	
	5	Stimulus	Decrease traffic generating by 6N1 to 0 packet per slot frame	
	6	IOP Check	Check 6N1 sends a 6P DELETE request to the DR, asking for deleting a number of cells equal to SF0THRESH	
	7	Stimulus	The 6N1 sends a 6P COUNT request to the DR	
	8	IOP Check	Check the counter value received is 1	
IOP Verdict				

6.8 SECJOIN

Test 32 -TD_6TiSCH_SECJOIN_01

Test Number	32			
Test ID	TD_6TiSCH_SECJOIN_01			
Test Objective	check that the join request is correctly received at the JRC			
Configuration	topology => a DAG root and a Pledge within range (single hop) both devices implement draft-ietf-6tisch-minimal-security-03 [i.19] configure a join key on the Pledge (using the well-known value defined at the beginning of this test description) configure the same join key for that Pledge on the JRC link-layer security is enabled			
References	IEEE 802.15.4-2015 [i.17], IETF RFC 8180 [i.2], draft-ietf-6tisch-minimal-security-03 [i.19]			
Pre-test conditions	DAG root and Pledge are turned off			
Test sequence	Step	Type	Description	Result
	1	Stimulus	turn on the DAG root turn on the Pledge	
	2	IOP Check	the Pledge synchronizes to the DAG root	
	3	IOP Check	the JRC receives a join request from the Pledge which is protected with OSCOAP and correctly formatted according to draft-ietf-6tisch-minimal-security-03	
IOP Verdict				

Test 33 -TD_6TiSCH_SECJOIN_02

Test Number	33			
Test ID	TD_6TiSCH_SECJOIN_02			
Test Objective	check that the join response is correctly received at the Pledge			
Configuration	same as TD_6TiSCH_SECJOIN_01			
References	same as TD_6TiSCH_SECJOIN_01			
Pre-test conditions	same as TD_6TiSCH_SECJOIN_01			
Test sequence	Step	Type	Description	Result
	1	Stimulus	repeat all steps from TD_6TiSCH_SECJOIN_01	
	2	IOP Check	the Pledge receives a Join Response from the JRC (how this is verified is implementation specific, for example by having an LED go on)	
	3	Stimulus	issue a "ping" command to the Pledge	
	4	IOP Check	the ping is successful, indicating the Pledge has received and configured the right K2 in the join response	
IOP Verdict				

Test 34 -TD_6TiSCH_SECJOIN_03

Test Number	34			
Test ID	TD_6TiSCH_SECJOIN_03			
Test Objective	check that JP correctly forwards (proxies) the Join Request to the JRC, on behalf of the Pledge			
Configuration	multi-hop			
References	IEEE 802.15.4-2015 [i.17], IETF RFC 8180 [i.2], draft-ietf-6tisch-minimal-security-03 [i.19]			
Pre-test conditions	topology => two-hop topology a DAG root a first 6N within range of the DAG root, playing the role of JP a second 6N within range of the JP, but not of the DAG root, playing the role of Pledge this two-hop topology can be emulated by implementing MAC address filtering at the devices all devices implement draft-ietf-6tisch-minimal-security-03 configure a join key on the Pledge (using the well-known value defined at the beginning of this test description) configure the same join key for that Pledge on the JRC link-layer security is enabled			
Test sequence	Step	Type	Description	Result
	1	Stimulus	switch on the DAG root switch on the JP switch on the Pledge	
	2	IOP Check	the JP synchronizes to the DAG root	
	3	IOP Check	the Pledge synchronizes to the JP	
	4	IOP Check	the JP receives a join request from the Pledge, protected with OSCOAP and correctly formatted according to draft-ietf-6tisch-minimal-security-03	
	5	IOP Check	the JRC receives a join request from the JP, on behalf of Pledge, protected with OSCOAP and correctly formatted according to draft-ietf-6tisch-minimal-security-03	
IOP Verdict				

Test 35 -TD_6TiSCH_SECJOIN_04

Test Number	35			
Test ID	TD_6TiSCH_SECJOIN_04			
Test Objective	check that the join response is correctly received at the Pledge (after having been proxied by the JP)			
Configuration	same as TD_6TiSCH_SECJOIN_03			
References	same as TD_6TiSCH_SECJOIN_03			
Pre-test conditions	same as TD_6TiSCH_SECJOIN_03			
Test sequence	Step	Type	Description	Result
	1	Stimulus	repeat all steps from TD_6TiSCH_SECJOIN_03	
	2	IOP Check	the Pledge receives a join response from the JP (how this is verified is implementation specific, for example by having an LED go on)	
	3	IOP Check	issue a "ping" command to the Pledge	
	4	IOP Check	the ping is successful, indicating the Pledge has received and configured the right K2 in the join response	
IOP Verdict				

Test 36 -TD_6TiSCH_SECJOIN_05

Test Number	36			
Test ID	TD_6TiSCH_SECJOIN_05			
Test Objective	Resistance to alteration of requests			
Configuration	multi-hop			
References	same as TD_6TiSCH_SECJOIN_03			
Pre-test conditions	all conditions from TD_6TiSCH_SECJOIN_03 link-layer security is disabled in order to facilitate automated testing with a sniffer on the JP to JRC path configure the JP to act maliciously and alter random bits in join requests that it forwards			
Test sequence	Step	Type	Description	Result
	1	Stimulus	switch on the DAG root switch on the JP switch on the Pledge	
	2	IOP Check	the JP synchronizes to the DAG root	
	3	IOP Check	the Pledge synchronizes to the JP	
	4	IOP Check	the JP receives a join request from the Pledge which is protected with OSCOAP	
	5	IOP Check	the JRC receives a join request from the JP, on behalf of Pledge, which is protected with OSCOAP; this join request will have been forwarded and altered by the JP so that the MIC check at JRC fails	
	6	IOP Check	the JP receives a 4.00 Bad Request error from JRC with a Stateless-Proxy option set	
	7	IOP Check	the Pledge receives a 4.00 Bad Request error from the JP	
IOP Verdict				

Test 37 -TD_6TiSCH_SECJOIN_06

Test Number	37			
Test ID	TD_6TiSCH_SECJOIN_06			
Test Objective	Resistance to replay of requests			
Configuration	multi-hop			
References	same as TD_6TiSCH_SECJOIN_03			
Pre-test conditions	all conditions from TD_6TiSCH_SECJOIN_03 link-layer security is disabled in order to facilitate automated testing with a sniffer on the JP to JRC path configure the JP to act maliciously and replay the join requests it has forwarded			
Test sequence	Step	Type	Description	Result
	1	Stimulus	repeat all steps from TD_6TiSCH_SECJOIN_03	
	2	IOP Check	the Pledge receives a Join Response from the JRC (how this is verified is implementation specific, for example by having an LED go on)	
	3	IOP Check	the JRC receives a replayed Join Request, sent by the JP	
	4	IOP Check	the JP receives a 4.00 Bad Request error from the JRC	
IOP Verdict				

Test 38 -TD_6TiSCH_SECJOIN_07

Test Number	38			
Test ID	TD_6TiSCH_SECJOIN_07			
Test Objective	Resistance to eavesdropping			
Configuration	multi-hop			
References	same as TD_6TiSCH_SECJOIN_03			
Pre-test conditions	all conditions from TD_6TiSCH_SECJOIN_03 link-layer security is disabled in order to facilitate automated testing with a sniffer on the JP to JRC path configure the JP to act maliciously and attempt the inspection of join responses			
Test sequence	Step	Type	Description	Result
	1	Stimulus	repeat all steps from TD_6TiSCH_SECJOIN_03	
	2	IOP Check	the JP receives a Join Response from the JRC	
	3	IOP Check	the JP attempts at parsing the Join Response contents and fails (how this is verified is implementation specific, for example by having an LED go on)	
IOP Verdict				

Test 39 -TD_6TiSCH_SECJOIN_08

Test Number	39			
Test ID	TD_6TiSCH_SECJOIN_08			
Test Objective	Detection of flaws in the authentication			
Configuration	multi-hop			
References	same as TD_6TiSCH_SECJOIN_03			
Pre-test conditions	all conditions from TD_6TiSCH_SECJOIN_03 link-layer security is disabled in order to facilitate automated testing with a sniffer on the JP to JRC path configure a join key on the Pledge different from the well-known value defined at the beginning of this test description			
Test sequence	Step	Type	Description	Result
	1	Stimulus	repeat all steps from TD_6TiSCH_SECJOIN_03	
	2	IOP Check	the JP receives a 4.00 Bad Request error from the JRC with Stateless-Proxy option set	
	3	IOP Check	the Pledge receives a 4.00 Bad Request error from the JP	
IOP Verdict				

6.9 BBR-ND

Test 40 -TD_6TiSCH_BBR-ND_01

Test Number	40			
Test ID	TD_6TISCH_BBR-ND_01			
Test Objective	Check registration of nodes to BBR based on ND			
Configuration	BBR_1			
References	draft-ietf-6lo-backbone-router-01 [i.20], IETF RFC 6775 [i.14]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. Nodes sends EB packets on a single frequency. Power on DR/6LBR. Power on 6BBR. Wait until all the 6N1 and 6N2 join the network. Ensure a linear topology. 6N1 acts as joining node. 6N2 acts as 6LR. DR acts as 6LBR. 6BBR is the backbone router where 6LBR is connected.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	6N1 sends NS(EARO) to 6LR(6N2) T=1 TID=1 OUID=6N1 EUI64 and lifetime > 0.	
	2	IOP Check	Check 6LR sends DAR (EARO) to 6LBR. Destination address is 6LBR address. Source address is 6LR address. The Registered address is 6N1 address. EUI64 and Lifetime are copied from EARO. Check status = 0.	
	3	IOP Check	6LBR sends NS (EARO) to 6BBR. Target=6N1 address SLLA=6LBR, UID=EUI64 6N1 TID=1.	
	4	IOP Check	6BBR sends NS DAD (EARO) to the backbone. After >800m 6BBR timeouts.	
	5	IOP Check	6BBR sends NA (EARO) Status = 0 to 6LBR. Target is 6N1.	
	6	IOP Check	6LBR sends DAC (EARO) to 6LR. The status is 0.	
	7	IOP Check	6N1 receives an NA(EARO) with status = 0.	
IOP Verdict				

Test 41 -TD_6TiSCH_BBR-ND_02

Test Number	41			
Test ID	TD_6TISCH_BBR-ND_02			
Test Objective	Check registration of nodes to BBR based on RPL			
Configuration	BBR_1			
References	draft-ietf-6lo-backbone-router-01 [i.20], IETF RFC 6775 [i.14]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. Nodes sends EB packets on a single frequency. Power on DR/6LBR. Power on 6BBR. Wait until all the 6N1 and 6N2 join the network. Ensure a linear topology. 6N1 acts as joining node. 6N2 acts as 6LR. DR acts as 6LBR. 6BBR is the backbone router where 6LBR is connected.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	6LR sends DAO to 6LBR. Destination address is Parent or Root address. Source address is 6LR address. Target is 6N1. TID included in transit option.	
	2	IOP Check	6LBR sends NS (ARO) to 6BBR. Target=6N1 address SLLA=6LBR, UID=EUI64 6N1 TID=1.	
IOP Verdict				

Test 42 -TD_6TiSCH_BBR-ND_03

Test Number	42			
Test ID	TD_6TISCH_BBR-ND_03			
Test Objective	Check de-registration of nodes to the Backbone router			
Configuration	BBR_1			
References	draft-ietf-6lo-backbone-router-01, IETF RFC 6775 [i.14]			
Pre-test conditions	The DR sends EBs periodically, with a fast rate (equal to 10 sec, according to IEEE 802.15.4 [i.17]), so that the 6N does not need to send KAs for keeping synchronization. All IUT sends EB packets on a single frequency. Power on DR/6LBR. Power on 6BBR. Wait until all the 6N1 and 6N2 join the network. Ensure a linear topology. 6N1 acts as joining node. 6N2 acts as 6LR. DR acts as 6LBR. 6BBR is the backbone router where 6LBR is connected.			
Test sequence	Step	Type	Description	Result
	1	Stimulus	6N1 sends NS (EARO) to 6LR (6N2) with T=1 TID=2 OUID=6N1 EUI64 and lifetime = 0.	
	2	IOP Check	Check 6LR sends DAR (EARO) to 6LBR. Destination address is 6LBR address. Source address is 6LR address. The Registered address is 6N1 address. EUI64 and Lifetime are copied from EARO. Check status = 0.	
	3	IOP Check	6LBR sends NS (EARO) to 6BBR. Target=6N1 address, OUID=EUI64 6N1 TID=2.	
	4	IOP Check	6BBR sends NA(EARO) Status = 4 to 6LBR.	
	5	IOP Check	6LBR sends DAC to 6LR1. The status is 4.	
	6	IOP Check	6N1 receives an NA(EARO) with status = 4 after.	
IOP Verdict				

Test 43 -TD_6TiSCH_BBR-ND_04

Test Number	43			
Test ID	TD_6TISCH_BBR-ND_04			
Test Objective	Check that a node can move to another backbone router while still keeping the registration.			
Configuration	BBR_2			
References	draft-ietf-6lo-backbone-router-01, IETF RFC 6775 [i.14]			
Pre-test conditions	The DR1 and DR2 send EB periodically, every 10 sec. All EB packets are sent on a single frequency. Power on DR1/6LBR2 and DR2/6LBR2. Power on 6BBR1. Power on 6BBR2. Wait until all the 6N1, 6N2 join the 6LBR1 network. Ensure a linear topology. 6N1 acts as joining node. 6N2 acts as 6LR (6LR1). DR1 acts as 6LBR (6LBR1). 6BBR1 is the backbone router where 6LBR1 is connected. 6N3 acts as 6LR (6LR2). DR2 acts as 6LBR2. 6LBR2 is connected to 6BBR2. 6N1 joins the 6BBR1 registers to the network.			
Test sequence	Step	Type	Description.	Result
	1	Stimulus	Connect 6N1 to the 6LR2 (movement).	
	2	Stimulus	6N1 sends NS (EARO) to 6LR2 (6N3) with T=1 TID=2 OUID=6N1 EUI64 and lifetime >0.	
	3	IOP Check	Check 6LR2 sends DAR (EARO) to 6LBR2. Destination address is 6LBR2 address. Source address is 6LR2 address. The Registered address is 6N1 address. EUI64 and Lifetime are copied from EARO. Check status = 0.	
	4	IOP Check	6LBR2 sends NS (EARO) to 6BBR2. Target=6N1 address SLLA=6LBR, UID=EUI64 6N1 TID=2.	
	5	IOP Check	6BBR2 sends NS DAD (EARO) multicast. It is received by 6BBR1 6BBR2 timeouts after 800 ms.	
	6	IOP Check	6BBR1 sends NA (ARO) status = 0 to 6BBR2.	
	7	IOP Check	6BBR2 sends NA (ARO) Status = 0 to 6LBR2.	
	8	IOP Check	6LBR2 sends DAC to 6LR2. The status is 0.	
	9	IOP Check	6N1 receives an NA (EARO) with status = 0.	
	10	IOP Check	6BBR1 sends NA (EARO) status = 3 to 6LBR1.	
	11	IOP Check	6LBR1 sends DAC (EARO) status = 3 to 6LR1.	
IOP Verdict				

Test 44 -TD_6TiSCH_BBR-ND_05

Test Number	44			
Test ID	TD_6TISCH_BBR-ND_05			
Test Objective	Check that a collision is detected when a node registers to the backbone with an already registered EUI64			
Configuration	BBR_2			
References	draft-ietf-6lo-backbone-router-01, IETF RFC 6775 [i.14]			
Pre-test conditions	The DR1 and DR2 send EB periodically, every 10 sec. All IUT sends EB packets on a single frequency. Power on DR1/6LBR2 and DR2/6LBR2. Power on 6BBR1. Power on 6BBR2. Wait until all the 6N1, 6N2 join the 6LBR1 network. Ensure a linear topology. 6N1 acts as joining node. 6N2 acts as 6LR (6LR1). DR1 acts as 6LBR (6LBR1). 6BBR1 is the backbone router where 6LBR1 is connected. 6N3 acts as 6LR (6LR2). DR2 acts as 6LBR2. 6LBR2 is connected to 6BBR2. 6N1 joins the 6BBR1. Registers to the network.			
Test sequence	Step	Type	Description.	Result
	1	Stimulus	Connect 6N1 to the 6LR2 (duplicate registration).	
	2	Stimulus	6N1 sends NS (EARO) to 6LR2 (6N3) with T=1 TID=1 (same TID) OUID=6N1 EUI64 and lifetime >0.	
	3	IOP Check	Check 6LR2 sends DAR (EARO) to 6LBR2. Destination address is 6LBR2 address. Source address is 6LR2 address. The Registered address is 6N1 address. EUI64 and Lifetime are copied from EARO. Check status = 0.	
	4	IOP Check	6LBR2 sends NS (EARO) to 6BBR2. Target=6N1 address SLLA=6LBR, UID=EUI64 6N1 TID=1.	
	5	IOP Check	6BBR2 sends NS DAD (EARO) multicast. It is received by 6BBR1. Collision is detected.	
	6	IOP Check	6BBR1 sends NA(ARO) Status = 1 to 6BBR2 (collision).	
	7	IOP Check	6BBR2 sends NA(ARO) Status = 1 to 6LBR2.	
	8	IOP Check	6LBR2 sends DAC to 6LR2. The status = 1.	
	9	IOP Check	6N1 receives an NA(EARO) with status = 1.	
IOP Verdict				

Annex A: Default Parameters

A.1 IEEE 802.15.4 Default Parameters

A.1.1 Address length

All IEEE 802.15.4 addresses will be long (64-bit), because association is not part of [i.2].

The only exception is the broadcast address, 0xffff.

A.1.2 Frame version

All IEEE 802.15.4 frames will be of version 2 (b10).

A.1.3 PAN ID compression and sequence number

All IEEE 802.15.4 frames will contain the following field:

- a source address,
- a destination address,
- a sequence number,
- a destination PANID (no source PANID).

A.1.4 Payload termination IE

The IE payload list termination will NOT be included in the EB.

A.1.5 IANA for 6P IE related

Since they have not been defined by IANA, for the Interop test, the following values are being used:

IANA_GROUP_ID_SIXTOP_IE	0x02
IANA_SIXTOP_SUB_IE_ID	0x00
IANA_SIXTOP_VERSION	0x01
IANA_SFID_SF0	0x00
IANA_6TOP_CMD_ADD	0x01
IANA_6TOP_CMD_DELETE	0x02
IANA_6TOP_CMD_COUNT	0x03
IANA_6TOP_CMD_LIST	0x04
IANA_6TOP_CMD_CLEAR	0x05
IANA_6TOP_RC_SUCCESS	0x06

IANA_6TOP_RC_VER_ERR 0x07

IANA_6TOP_RC_SFID_ERR 0x08

IANA_6TOP_RC_BUSY 0x09

IANA_6TOP_RC_RESET 0x0a

IANA_6TOP_RC_ERR 0x0b

A.1.6 6P Timeout

A timeout happens when the node sending the 6P Request has not received the 6P Response. The value of the timeout is set to 4 seconds during the tests.

A.1.7 RPL Operation Mode

There are two modes for a RPL Instance to choose for maintaining downward routes: Storing and Non-Storing modes. The Non-Storing mode is used during the tests.

A.2 Default Security Keys

To perform the SEC-related tests (test#17 and test#18), the value of key K1 will be set according to IETF RFC 8180 [i.2], while the value of K2 will be set to `deadbeeffacecafe` per default. Moreover, Key Index (advertised in the auxiliary security header of the packet), will be used for K1 and K2, to enable nodes to look up the right key before decrypting.

A.3 IP in IP Encapsulation

A.3.1 Context

Hereafter is an example of how the IP in IP encapsulation works, when in a multi-hop (linear) scenario a 6N sends a message to a DR acting as Low power and lossy network Border Router (LBR). Let us assume the DR and the two 6Ns have the following addresses:

```
Address of DR (LBR): bbbb::1

Address of 6N1: bbbb::1415:92cc:0:2

Address of 6N2: bbbb::1415:92cc:0:3
```

To the aim of this test, DR and 6N2 cannot communicate directly, while 6N1 can communicate with both DR and 6N2. The DR generates an ICMPv6 Echo Request message for 6N2, which will be forwarded by 6N1 to 6N2. After reception of the echo Request, the 6N2 generates an ICMPv6 Echo Response message which will be forwarded by 6N1 to DR.

A.3.2 Echo Request sent from DR to 6N1 (containing source routing header)

```
7c 00 3e bb bb 00 00 00 00 00 00 00 00 00 00 00 00 01 bb bb 00 00 00 00 00 00 14 15 92 cc 00 00
00 02 e3 0e 03 01 88 00 00 00 14 15 92 cc 00 00 00 03 ee 78 33 3a 3e ......

IPHC outer header:
       0   1   2   3   4   5   6   7   8   9   0   1   2   3   4   5
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
     | 0 | 1 | 1 |  TF   |NH | HLIM  |CID|SAC|  SAM  | M |DAC|  DAM  |
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
7c 00:  0   1   1   1   1   1   0   0   0   0   0   0   0   0   0   0
```

```
Hop limitation: 3e
Source:        bb bb 00 00 00 00 00 00 00 00 00 00 00 00 00 01
Destination:    bb bb 00 00 00 00 00 00 14 15 92 cc 00 00 00 02

RH3 header:
            0   1   2   3   4   5   6   7
                     +---+---+---+---+---+---+---+---+
                     | 1 | 1 | 1 | 0 |    EID    |NH |
                     +---+---+---+---+---+---+---+---+
e3:                     1   1   1   0   0   0   1   1
Routing Header:
Hdr Ext Len :   0e
Routing type:   03
Segments left:  01
CmprI:          8
CmprE:          8
Pad:            0
Reserved:       0 00 00
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
                     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                |  Hdr Ext Len  | Routing Type  | Segments Left |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |CmprI:8| CmprE |  Pad  |               Reserved              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                    0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1
      1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
RH3 Vector of addresses:
14 15 92 cc 00 00 00 03

IPv6 extension header:
                       0   1   2   3   4   5   6   7
                     +---+---+---+---+---+---+---+---+
                     | 1 | 1 | 1 | 0 |    EID    |NH |
                     +---+---+---+---+---+---+---+---+
EE:                    1   1   1   0   1   1   1   0

IPHC inner header:
       0   1   2   3   4   5   6   7   8   9   0   1   2   3   4   5
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
     | 0 | 1 | 1 |  TF   |NH | HLIM  |CID|SAC|  SAM  | M |DAC|  DAM  |
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
78 33:  0   1   1   1   1   0   0   0   0   0   1   1   0   0   1   1
Next header: 3a (icmpv6)
Hop limit:  3e
```

A.3.3 Echo Reply sent from 6N2 to 6N1 (containing RPL option)

```
7c 11 40 14 15 92 cc 00 00 00 03 00 00 00 00 00 00 00 01 e1 06 63 04 00 00 05 a1 ee 7a 13
3a 14 15 92 cc 00 00 00 03......

IPHC outer header:
       0   1   2   3   4   5   6   7   8   9   0   1   2   3   4   5
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
     | 0 | 1 | 1 |  TF   |NH | HLIM  |CID|SAC|  SAM  | M |DAC|  DAM  |
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
7c 11:  0   1   1   1   1   1   0   0   0   0   0   1   0   0   0   1
Hop limitation: 3f
Source:        (bbbb::) 14 15 92 cc 00 00 00 03
Destination:    (bbbb::) 00 00 00 00 00 00 00 01

Hop-by-Hop option header:
          0   1   2   3   4   5   6   7
                     +---+---+---+---+---+---+---+---+
                     | 1 | 1 | 1 | 0 |    EID    |NH |
                     +---+---+---+---+---+---+---+---+
e1:                     1   1   1   0   0   0   0   1

Hop-by-Hop option:
NH Length  :  06
Option Type:      63
```

```
Opt Data Len: 04
R:      0
F:      0
RPLInstanceID:    00
SenderRank:   05 a1
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
                                     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                     |  Option Type  |  Opt Data Len |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |O|R|F|0|0|0|0|0| RPLInstanceID |          SenderRank           |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                      0 0 0 0 0 1 1 0 0 1 1 0 0 0 1 1 0 0 0 0 0 1 0 0
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0

IPv6 extension header:
                       0   1   2   3   4   5   6   7
                     +---+---+---+---+---+---+---+---+
                     | 1 | 1 | 1 | 0 |    EID    |NH |
                     +---+---+---+---+---+---+---+---+
ee:                    1   1   1   0   1   1   1   0


IPHC inner header:
       0   1   2   3   4   5   6   7   8   9   0   1   2   3   4   5
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
     | 0 | 1 | 1 |  TF   |NH | HLIM  |CID|SAC|  SAM  | M |DAC|  DAM  |
     +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
7a 13:  0   1   1   1   1   0   1   0   0   0   0   1   0   0   1   1
Next header: 3a (icmpv6)
Source:        (bbbb::) 14 15 92 cc 00 00 00 03
Destination:    elided.
```

Annex B: Bibliography

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