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IEEE 1588 Test Handbook

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2 Modification Records

Revision	Date	Author	Comments
1.0	Feb 28	S. Schriegel	Draft test plan
1.1	Mar 3	H. Gerstung	more test cases and test network layouts
1.2	Mar 5	S. Schriegel	Test schedule and test sequences
1.3	Mar 9	H. Gerstung	Parameters for test sequences
1.5	Mar 11	S. Schriegel	Device list and more test parameter definitions
1.6	Mar 15	S. Schriegel	HSR, RSTP, Calnex Paragon, printer friendly format changes, figures added
2.0	Mar 21	H. Gerstung, S. Schriegel	More detailed test description and parameters, details test schedule, IP address scheme
2.2	Mar 23	H. Gerstung, S. Schriegel	final version
3.2	April 13	S. Schriegel	universal version ot the test handbook; independent of the 2011 IEEE 1588 Spring Plugfest in Lemgo; Legal Terms (Chapter 3)

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4 Test Environment

The tests are done in four network topology layouts: Chain, Ring, Star and Tree.

This chapter gives an overview of these layouts.

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4.1 Test Network Layouts (TNL)

This section describes the different test network layouts we are going to use in the tests. Each test has to define which oft he following layouts is used.

4.1.1 Layout A: Chain

- all switches in a chain
- grandmaster clocks connect to the head end and tail end switches
- slaves connected to all other switches

| GM | — | TC/ BC | — | TC/ BC | — | OC |
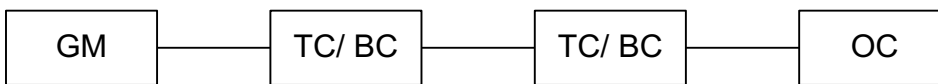
Figure 1: Layout A: Chain

4.1.2 Layout B: Ring

- all RSTP switches in ring topology
- all other switches connected to the ring
- grandmaster clocks connected to switches (max. number of hops between GMs)
- slaves connected to all switches

| GM | — | TC/ BC | — | TC/ BC | — | OC |
| | | TC/ BC | — | TC/ BC | — | OC |
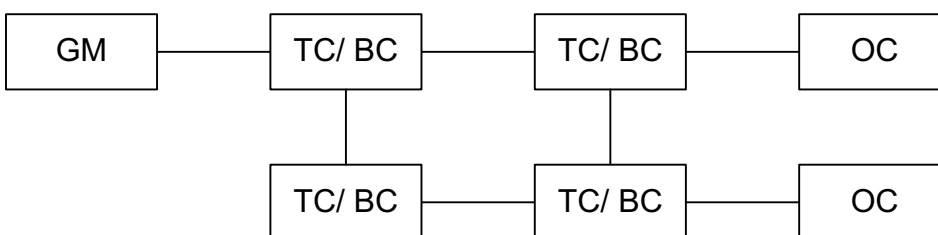
Figure 2: Layout B: Ring

4.1.3 Layout C: Star

- one central switch
- all other switches connected to this switch
- all grandmaster clocks connected to different edge-switches
- all slaves connected to other edge-switches
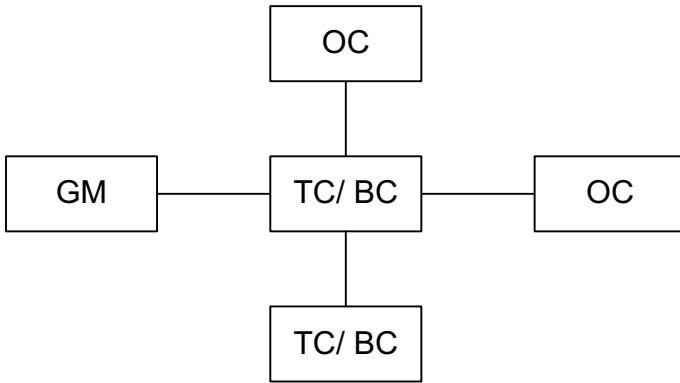
Figure 3: Layout C: Star

4.1.4 Layout D: Tree

- one central switch

- two other switches connected to this switch

- two other switches connected to each of these two switches and so on

- grandmaster clocks and slaves connected to the last line of switches

- if possible, network connections between masters and slaves should traverse the whole tree
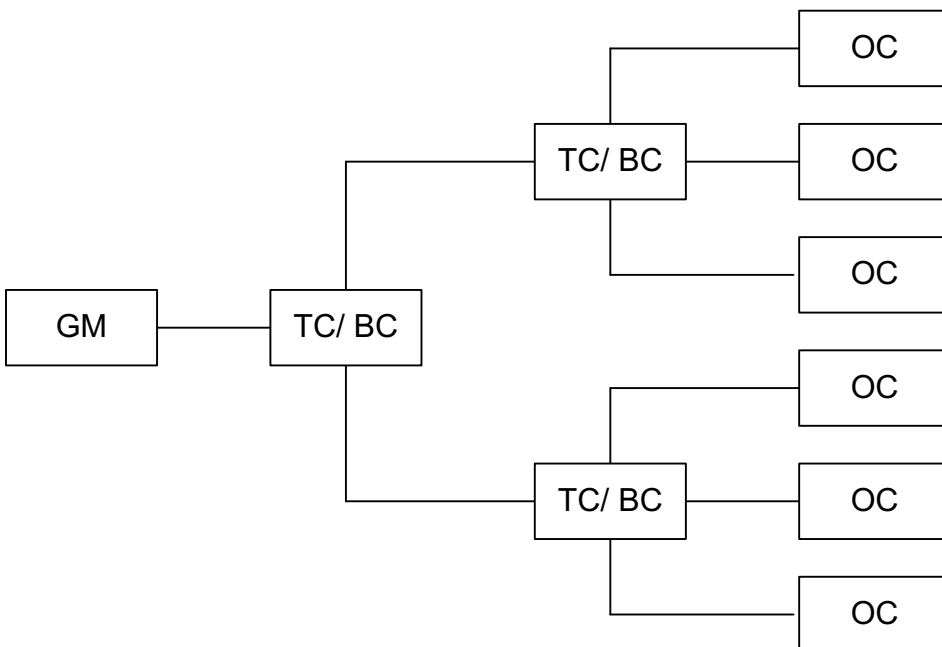
Figure 4: Layout D: Tree

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4.2 Tested PTP Profiles

In addition to various Default Profile tests (with changing parameters/modes), some tests are carried out using either the Telecom Profile (ITU G.8265.1) or the Power Profile (IEEE C37.238) in its current draft form. Whenever possible, it is allowed to participate with devices that either support the tested profile or can be configured to run in a compatible mode.

4.2.1 Default Profile

See the description of the Default Profile in IEEE 1588-2008. The tests are using different settings and modes, i.e. they use a variation of SYNC, ANNOUNCE and DELAY_REQ intervals and can be defined to use One-Step/Two-Step, Multicast/ Unicast, Layer 2 (Ethernet)/Layer 3 (TCP/IP) and End-to-End or Peer-to-Peer delay measurements.

4.2.2 Telecom Profile

The Telecom Profile as defined in ITU G.8265.1 is used with the following settings:

- Unicast
- One-Step and Two-Step
- Layer 3 (TCP/IP)
- Two-Way Delay Measurements using the End-to-End mechanism
- Message Rates vary, max. message rate are 32 packets/s for SYNC/DELAY_REQ and 8 packets/s for ANNOUNCE
- Unicast Message Negotiation (REQUEST_UNICAST_TRANSMISSION TLVs)
- Domain Number 4
- Announce Receipt Timeout 2

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4.2.3 Power Profile

The Power Profile as defined in IEEE C37.238 (currently in draft status) is used with the following settings:

- Multicast

- One-Step and Two-Step

- Layer 2 (Ethernet)

- Peer-To-Peer Delay Measurements

- Message Rates: 1/s SYNC, ANNOUNCE and PDELAY_REQ

- standard BMCA

- Announce Messages carry C37_238_TLV (or GRANDMASTER_ID_TLV) and ALTERNATE_TIMESCALE_TLV

- VLAN ID 0 (for some tests)or VLAN ID 1588 (for other tests)

Due to the open discussions around ClockInaccuracy (formerly known as TimeQuality), we do not require devices to send the new version of the TLV (containing the ClockInaccuracy field) but it would be good if devices would be tolerant enough to support receiving both TLV versions (old one without ClockInaccuracy and new one including it).

Recent discussions in the IEEE C37.238 working group circled around the possibility to increase the message rates for SYNC and ANNOUNCE. One or more tests are used increased message rates to test the impact of this, especially on the convergence and recovery performance of power profile slaves.

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5 Test Equipment

This chapter gives an overview about the equipment that is used for the tests.

5.1 Synchronization Accuracy

- Meinberg Measurement Server
    - 24 x PPS Timestamping Channels
    - Oregano Cards
    - www.meinberg.de
    - http://www.oregano.at
- Calnex Paragon
    - http://www.calnexsol.com/products/paragon
- Scopes

5.2 Traffic Capturing

- Anritsu MD 1230B
    - http://www.anritsu.com/en-US/Products-Solutions/Products/MD1230B.aspx
    - http://www.hs-owl.de/init/en/service/testlabor.html
- Calnex Paragon (PTP protocoll specific capturing)
    - http://www.calnexsol.com/products/paragon
- Meinberg Measurement Server (4 x GigE NIC)
    - www.meinberg.de
- Hilscher netAnlayzer

5.3 Netload Generation

- Anritsu MD1230B
    - http://www.anritsu.com/en-US/Products-Solutions/Products/MD1230B.aspx
    - http://www.hs-owl.de/init/en/service/testlabor.html
- OWITA FLEXEGEN
    - http://www.owita.de/downloads/FLEXEGEN_Flyer_EN.pdf

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5.4 Network Impairments: Bit Error Insertion and Message duplication

- OWITA FLEXEGEN
    - o http://www.owita.de/downloads/FLEXEGEN_Flyer_EN.pdf
- Anritsu MD1230B
    - o http://www.anritsu.com/en-US/Products-Solutions/Products/MD1230B.aspx
    - o http://www.hs-owl.de/init/en/service/testlabor.html
- Calnex Paragon
    - o http://www.calnexsol.com/products/paragon

5.5 Packet Delay Variation Generation

- WAN/ LAN-Emulator Packet Storm
    - o http://www.hs-owl.de/init/en/service/testlabor.html
- OWITA FLEXEGEN
    - o http://www.owita.de/downloads/FLEXEGEN_Flyer_EN.pdf
- Calnex Paragon
    - o http://www.calnexsol.com/products/paragon

5.6 PTP network Hierarchy Detection

- Meinberg Measurement Server (PTP Status Monitor Software determines DELAY_REQ from Slaves to GM Clock in E2E Mode)
    - o www.meinberg.de
    - o Solution for P2P requires Management Messages or Manual Check.

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6 Test Sequences and Parameters

This Chapter defines the planned profiles, sequences and parameters for the test networks. It is divided into several sections:

- Basic Synchronization Tests Setups (BASIC)
- Network Topology Changes (NTC)
- Network Impairment Tests (IMP)
- Packet Delay Variation (PDV)
- Convergence and Recovery (CaR)
- Time discontinuities (TD)

Every test description contains a starting point as well as definitions for the PTP settings and profiles used in this test. Any additional parameters like network load parameters or other impairment specifications are defined as well.

A test sequence shows the planned test procedure and indicates the required / planned time for each of the sequence steps.

The Message Rates are defined like this:
- **SYNC: 4/s**   → four SYNC messages per second
- **SYNC: 4s**   → one SYNC every four seconds
- **ANNOUNCE: 2/s**   → two SYNC messages per second
- **ANNOUNCE: 2s**   → one ANNOUNCE every two seconds
- **PDELAY: 1/s**   → one PDELAY REQ per second (= 1s)
- **DELAY: 32/s**   → thirty-two DELAY REQ every second
- **DELAY: 32s**   → one DELAY REQ every thirty-two seconds

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6.1 BASIC: Basic Synchronization Tests Setups

The Chapter defines Basic Test Setups which test the basic protocol functions like Best Master Clock Algorithm and Unicast Signalling Messages. We use different topologies and different settings in order to test the default profile as well as power and telecom profile modes.

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6.1.1 Basic Test A: Chain with Default Profile

This test checks that BMCA based on priority 1 is working correctly and that synchronization in general can be established between slaves and grandmaster clocks. The recorded measurements (PPS) show how good each slave synchronizes to the GM clock and what happens during transition from one GM to the other.

```
┌────────┐     ┌────────┐     ┌────────┐     ┌────────┐
│   GM   │─────│ TC/ BC │─────│ TC/ BC │─────│   OC   │
└────────┘     └────────┘     └────────┘     └────────┘
```

Figure 5: Layout A: Chain

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- TNL: A [Chain]
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40).
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off / disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM with the lowest priority 1 setting
3	00:05:00	Switch off / disconnect GM A (prio1=10)
4	00:07:00	Check that all slaves selected the GM with prio1=20
5	00:09:00	Switch off / disconnect GM B (prio1=20)
6	00:11:00	Check that all slaves selected the GM with prio1=30

EXPECTED TEST RESULTS:

- all slaves should have selected the same grandmaster clocks at step 2, 4 and 6

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.1.2 Basic Test B: Ring with Power Profile

This test repeats Basic Test A with different settings and a different topology, allowing both Power Profile and Default Profile slaves to participate.

```
┌──────┐   ┌────────┐   ┌────────┐   ┌──────┐
│  GM  │───│ TC/ BC │───│ TC/ BC │───│  OC  │
└──────┘   └────────┘   └────────┘   └──────┘
               │            │
           ┌────────┐   ┌────────┐   ┌──────┐
           │ TC/ BC │───│ TC/ BC │───│  OC  │
           └────────┘   └────────┘   └──────┘
```
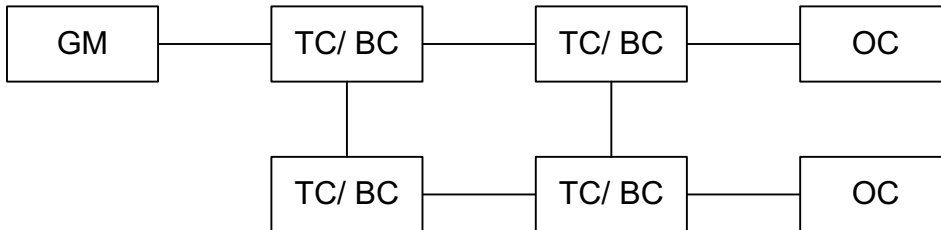
Figure 6: Ring with power profile (RSTP and HSR)

PROFILES:

- Default [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]
- Power Profile [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- TNL: B [RING]
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40). GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them.
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM with the lowest priority 1 setting
3	00:05:00	Switch off / disconnect GM A (prio1=10)
4	00:07:00	Check that all slaves selected the GM with prio1=20
5	00:09:00	Switch off / disconnect GM B (prio1=20)
6	00:11:00	Check that all slaves selected the GM with prio1=30

EXPECTED TEST RESULTS:

- all slaves should have selected the same grandmaster clocks at step 2, 4 and 6

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.1.3 Basic Test C: Tree with Telecom Profile
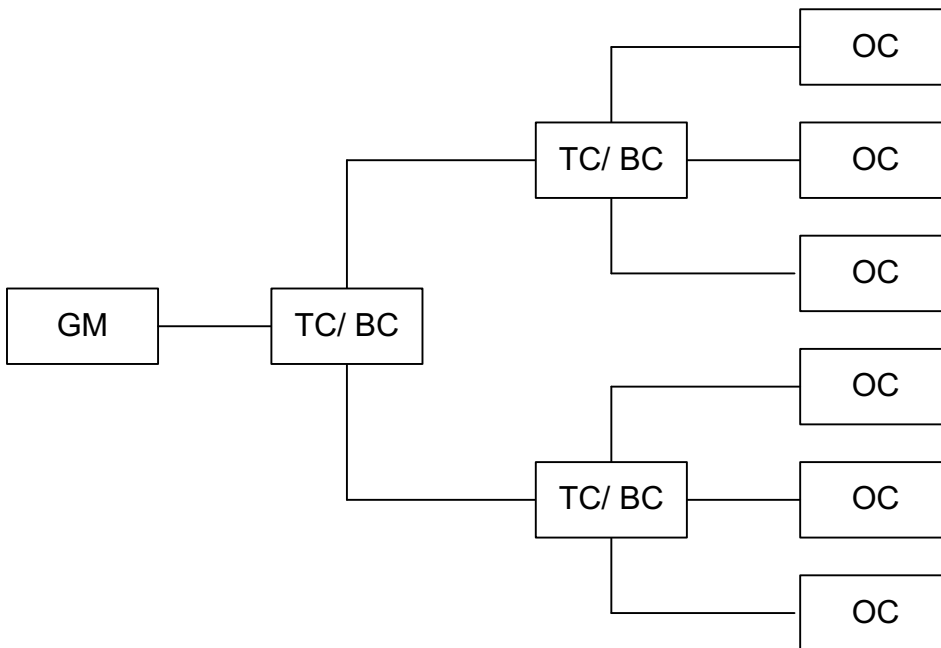
Figure 7: Tree topology with telecom profile

PROFILES:

- Default [Unicast Layer 3, E2E Delay Mechanism, SYNC: 16/s, ANNOUNCE: 2/s, DELAY: 8/s]
- Telecom [Unicast Layer 3, E2E Delay Mechanism, SYNC: 16/s, ANNOUNCE: 2/s, DELAY: 8/s]

EXPECTED DURATION:

00:12:00

STARTING POINT:

- TNL: C [STAR]
- GM configuration: Unicast Master
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected, configured to use the GM as their primary unicast master

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves established unicast negotiation with configured GM A
3	00:05:00	Switch off / disconnect all GM As
4	00:07:00	Check that all slaves selected their GM Bs
5	00:09:00	Reconnect/restart GM As
6	00:10:00	Switch off / disconnect GM Bs
7	00:12:00	Check that all slaves re-selected their GM As

EXPECTED TEST RESULTS:

- all slaves should have selected their correct grandmaster clocks at step 2, 4 and 7

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.2 NTC: Network Topology Changes

This section repeats the Basic Tests (5.1). In addition to that the network topology becomes changed during the test sequences.

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6.2.1 NTC Test A: Break Up a Chain

This test checks that BMCA based on priority 1 is working correctly and that synchronization in general can be maintained between slaves and grandmaster clocks during topology changes. The recorded measurements (PPS) show how good each slave synchronizes to the GM clock and what happens during transition from one GM to the other.
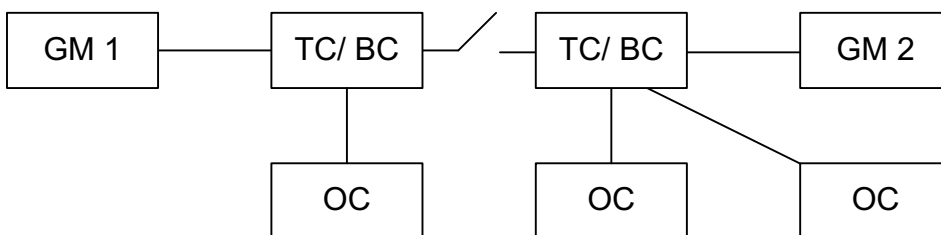
Figure 8: Chain Topologie with two GM

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- TNL: A (CHAIN)
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- GM Prio1=10 is attached to the head end switch
- GM Prio1=20 is attached to the tail end switch
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Break up the chain so that the network is split into two islands
4	00:07:00	Check that all slaves are synchronized to either GM Prio1=10 or =20, depending on their position in either island 1 or 2
5	00:09:00	Reconnect the two networks
6	00:11:00	Check that all slaves are now synchronized to GM Prio1=10

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test
- the synchronization accuracy offsets during the topology change should stay within specifications (for each slave)

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.2.2 NTC Test B: Open and Close a Ring

This test repeats Basic Test B, allowing both Power Profile and Default Profile slaves to participate. During the test, a simulated link failure causes a topology change
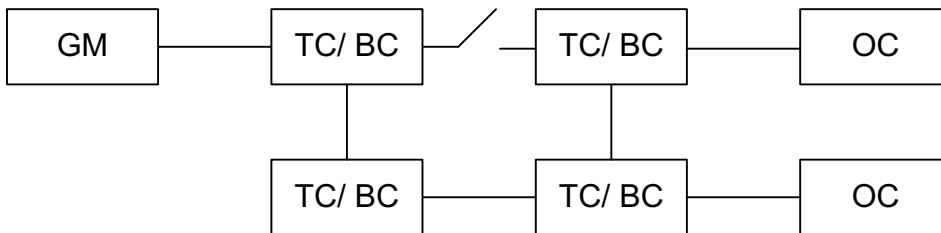
Figure 9: Ring Topologie

PROFILES:

- Default [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]
- Power Profile [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- TNL: B (RING)
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40). GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them
- GM Prio1=10 is attached to Switch A which is connected to Switch B and Switch N
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Open the ring by disconnecting Switch A from Switch N
4	00:07:00	Check that all slaves are still synchronized
5	00:09:00	Close the ring again
6	00:11:00	Check that all slaves are still synchronized

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test
- the synchronization accuracy offsets during the topology change
- no sync accuracy impairment (should be prevented with P2P)

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.2.3 NTC Test C: Splitting a Tree
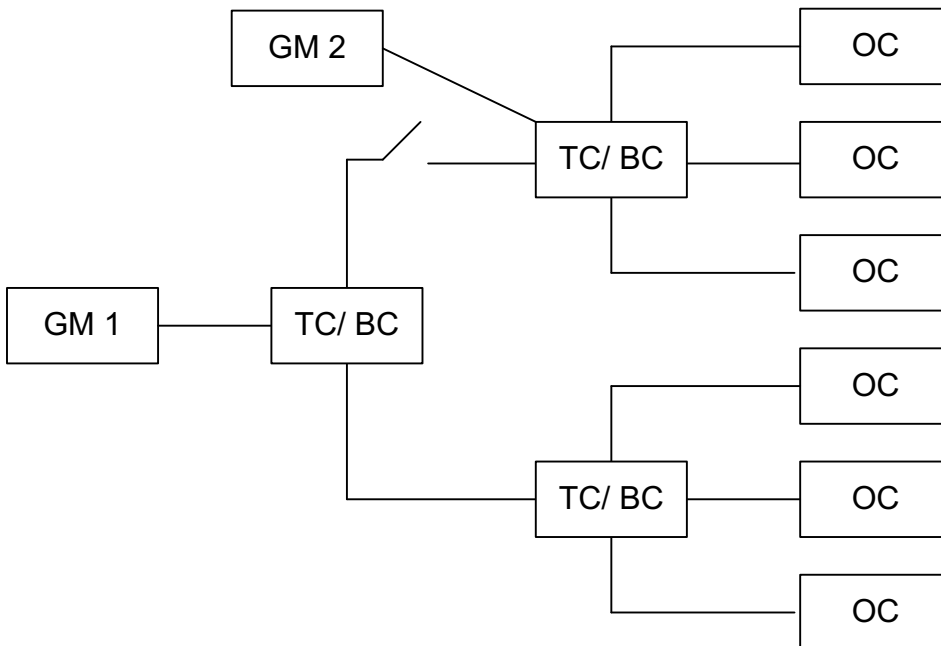
Figure 10: Tree Toplogogy with two GM

PROFILES:

- Default [Unicast Layer 3, E2E Delay Mechanism, SYNC: 16/s, ANNOUNCE: 2/s, DELAY: 8/s]
- Telecom [Unicast Layer 3, E2E Delay Mechanism, SYNC: 16/s, ANNOUNCE: 2/s, DELAY: 8/s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- GM Configuration: Unicast Master
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off / disconnected, configured to use GM A as their primary unicast master and GM B as their backup master (each Slave can pick different GM A and GM B)
- Switch A is the "root" switch, it is connected to Switch B and C
- Grandmaster Clocks used as GM A should be connected to Switch B and Grandmaster Clocks used as GM B should be connected to Switch C

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves synchronized to their primary GM
3	00:05:00	Disconnect Switch A and C, effectively splitting the network into two islands
4	00:07:00	Check that all slaves in island 1 (Switch B) are still synchronized to GM A and all slaves in island 2 (Switch C) are now synchronized to GM B
5	00:09:00	Reconnect Switch A and C, re-joining the two networks
6	00:11:00	Check that all slaves are synchronized to their GM A (or stayed with GM B, depending on their expected behaviour)

EXPECTED TEST RESULTS:

- all slaves should have selected their correct grandmaster clocks at step 2, 4 and 7

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.3 IMP: Network Impairment Tests

The Basic Tests repeates while traffic is going to be injected into the network during the test sequences. Further on PTP messages are dropped and frames are going to be damaged by error insertions.

Equipment:

- WAN-Emulator Packetstorm
- OWITA FLEXEGEN
- Calnex Paragon

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6.3.1 IMP Test A: Traffic Injection in a Chain

Additional traffic becomes injected in an intermediate switch between GM and slaves.
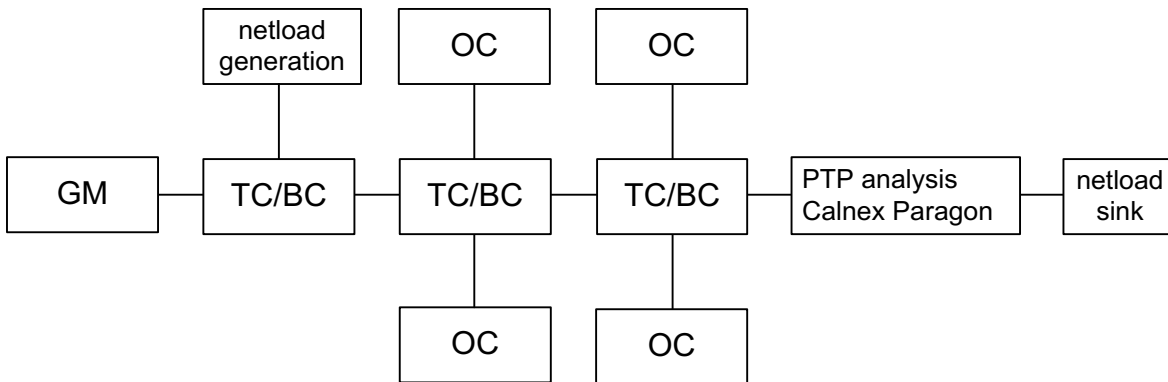
Figure 11: Traffic injection in an intermediate switch

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- TNL: A [Chain]
- GM Configuration: Each GM has its own priority1 setting (10,20,30,40
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

IMPAIRMENT PARAMETERS:

- Unicast
- Frame length (RFC 2544 and RFC 1242)
- 50% of the frames with VLAN prioritisation
- Throughput impairment traffic (10%, 20%, 40%, 60%, 80%, 100%)

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Inject defined traffic in the intermediate switch
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:09:00	Stop injecting additional traffic
6	00:11:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:

- all slaves should remain synchronized during the whole test
- all GMs with Prio1>10 should remain PASSIVE during the whole test
- the synchronization accuracy offsets for each slave during the impairment stay within the expected limits

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.3.2 IMP Test B: Traffic Injection in a Ring

Additional traffic becomes injected in the ring switch.
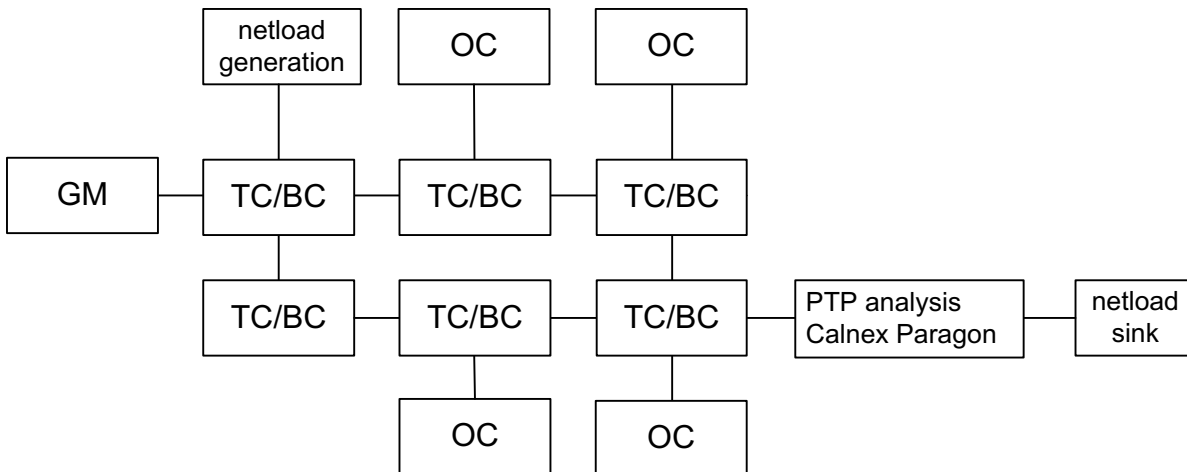
Figure 12: Traffic injection in the ring

PROFILES:

- Default [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]
- Power Profile [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

EXPECTED DURATION:

00:12:00

STARTING POINT:

- TNL: B (RING)
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40). GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

IMPAIRMENT PARAMETERS:

- Unicast

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- Frame length (RFC 2544 and RFC 1242)

- 50% of the frames with VLAN prioritisation

- Throughput impairment traffic (10%, 20%, 40%, 60%, 80%, 100%)

- Throughput impairment traffic

TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM with Prio1=10 and synchronized to it
3	00:05:00	Inject defined traffic in the intermediate switch
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:09:00	Stop injecting additional traffic
6	00:11:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:
- all slaves should maintain synchronization with GM Prio1=10 during the whole test
- the injected traffic should have no real impact on the accuracy of the slaves

TEST MEASUREMENTS:
- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.3.3 IMP Test C: Dropping, Error and Duplication in a Chain

Errors are inserted in the link between GM and slaves so that the frame check sequences are invalid. Ths causes layer two frame fragments In Cut Through switching mode. Store and forward switches drop invalid frames. Further on messages become duplicated.
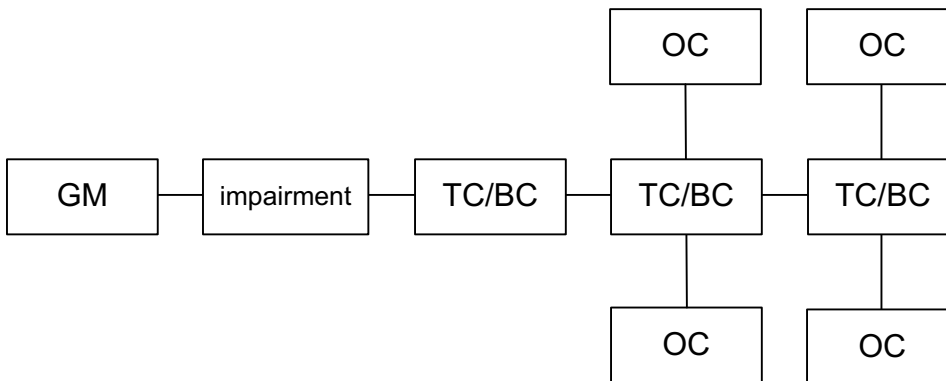
Figure 13: Impairment by OWITA FLEXEGEN and Calnex Paragon

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:15:00

STARTING POINT:

- TNL: A (CHAIN)
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

IMPAIRMENT PARAMETERS:

- Bit errors rate BER [Bit error per second]: 100; 1000; 2000; 4000; 8000; 16000

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM and synchronized
3	00:03:00	Start inserting Errors and Dropping frames in the link between GM and slaves by OWITA FLEXEGEN.
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:08:00	Stop inserting Errors in the link between GM and slaves. Disconnect OWITA FLEXEGEN and connect Calnex Paragon
6	00:09:00	Check that all slaves are still synchronized, measure the synchronization accuracy
7	00:10:00	Start duplicating frames by Calnex Paragon
8	00:11:00	Check that all slaves are still synchronized, measure the synchronization accuracy
8	00:14:00	Stop duplicating frames
9	00:16:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test
- the synchronization accuracy offsets during the impairments

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.3.4 IMP Test D: Dropping, Error and Duplication in a Ring

Messages become duplicated in the link between GM and slaves.
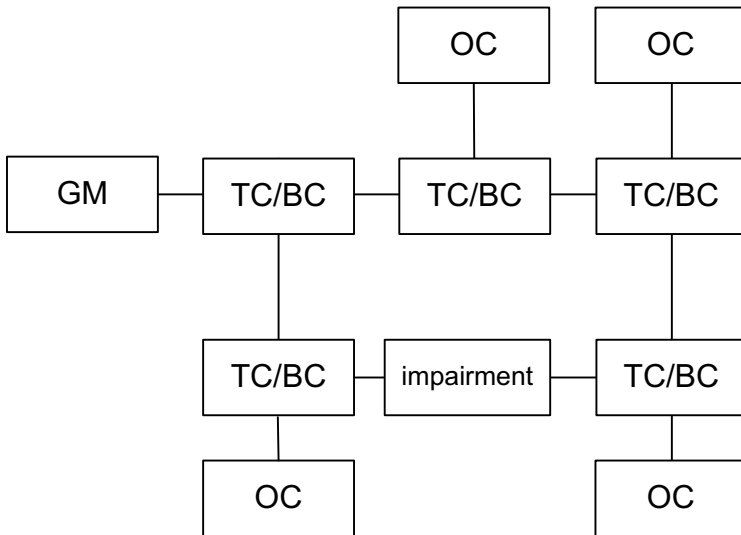
Figure 14: Traffic Impairment in the Ring

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:12:00

STARTING POINT:

- TNL: A (CHAIN)
- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

IMPAIRMENT PARAMETERS:

- Bit errors rate BER [Bit error per second]: 100; 1000; 2000; 4000; 8000; 16000

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM and synchronized
3	00:03:00	Start inserting Errors in the link between GM and slaves.
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:08:00	Stop inserting Errors in the link between GM and slaves.
6	00:09:00	Check that all slaves are still synchronized, measure the synchronization accuracy
7	00:10:00	Start duplicating frames
8	00:11:00	Start duplicating frames
9	00:12:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:
- all slaves should maintain synchronization during the whole test
- the synchronization accuracy offsets during the impairments

TEST MEASUREMENTS:
- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.4 PDV: Packet Delay Variation

The basic tests are repeated. In addition to that the delay of links becomes changed or PDV becomes introduced at certain points of the infrastructure.

Equipment:

- WAN-Emulator Packetstorm
- OWITA FLEXEGEN
- Calnex Paragon

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6.4.1 PDV Test A: Chain

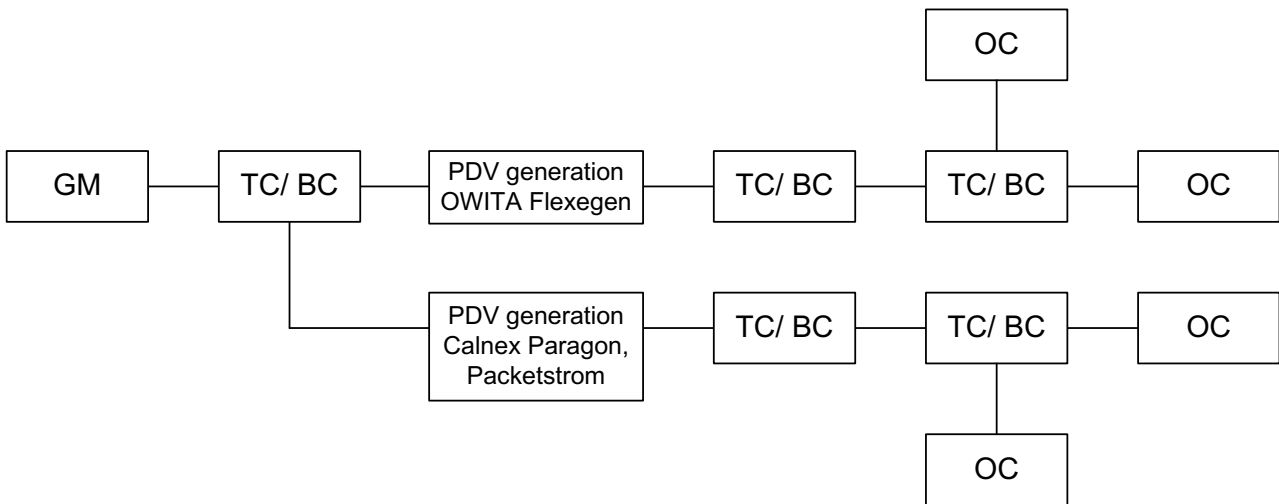The PDV becomes generated by OWITA FLEXEGEN and Calnex Paragon.

```
                                                    ┌──────┐
                                                    │  OC  │
                                                    └──────┘
                                                       │
┌──────┐   ┌───────┐  ┌──────────────┐  ┌───────┐  ┌───────┐  ┌──────┐
│  GM  │───│ TC/ BC│──│ PDV generation│──│ TC/ BC│──│ TC/ BC│──│  OC  │
└──────┘   └───────┘  │ OWITA Flexegen│  └───────┘  └───────┘  └──────┘
               │      └──────────────┘
               │      ┌──────────────┐  ┌───────┐  ┌───────┐  ┌──────┐
               │      │ PDV generation│──│ TC/ BC│──│ TC/ BC│──│  OC  │
               └──────│ Calnex Paragon,│ └───────┘  └───────┘  └──────┘
                      │ Packetstrom   │                 │
                      └──────────────┘             ┌──────┐
                                                    │  OC  │
                                                    └──────┘
```

Figure 15: PDV generation in two chains (one chain GB, one chain FE)

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:15:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

PDV PARAMETERS:

- ITU-T G.8261

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Start delay packets with OWITA FLEXEGEN (FE chain) and Calnex Paragon (GE chain)
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:09:00	Stop delay packets
3	00:10:00	Start delay packets with OWITA FLEXEGEN (FE chain) and WAN emulator Packetstorm (GE chain)
4	00:12:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:14:00	Stop delay packets
6	00:15:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.4.2 PDV Test B: Ring

This test are done in two ring topologies. One ring is used the redundancy protocol RSTP, the second ring works with the redundancy protocol HSR.
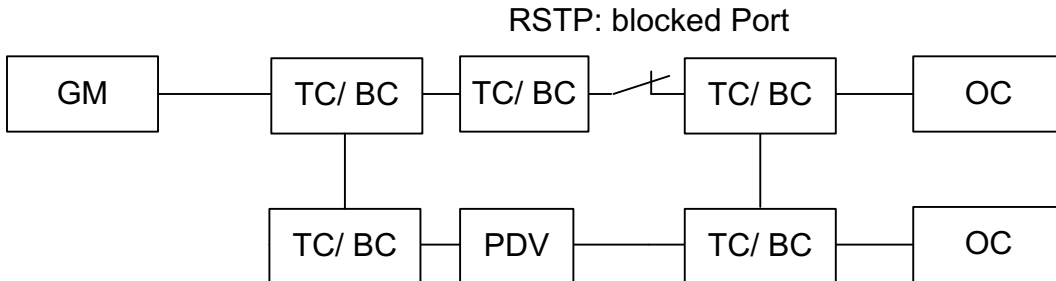
RSTP: blocked Port

```
┌──────┐   ┌───────┐ ┌───────┐    ┌───────┐   ┌──────┐
│  GM  │───│ TC/ BC│─│ TC/ BC│──/─│ TC/ BC│───│  OC  │
└──────┘   └───────┘ └───────┘    └───────┘   └──────┘
               │                      │
           ┌───────┐ ┌───────┐    ┌───────┐   ┌──────┐
           │ TC/ BC│─│  PDV  │────│ TC/ BC│───│  OC  │
           └───────┘ └───────┘    └───────┘   └──────┘
```

Figure 16: Ring with PDV injection

PROFILES:

- Default [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]
- Power Profile [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

EXPECTED DURATION:

00:11:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40).
- GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off / disconnected

PDV PARAMETERS:

- 500ns; 1µs; 2µs; 4µs; 8µs; 16µs; 32µs [symmetric delay/ asymmetric delay]
- Mapping of selected PDV profiles of ITU-T G.826 to Power Profile

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Start delay packets
4	00:07:00	Check that all slaves are still synchronized, measure the synchronization accuracy
5	00:09:00	Stop delay packets
6	00:11:00	Check that all slaves are still synchronized, measure the synchronization accuracy

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.5 CaR: Convergence and Recovery

- Let all slaves synchronize to a GM and then switch it off

- fire up a second GM with a static offset to GPS of several ms or even seconds

- measure how fast / smooth slaves re-establish synchronization with second GM

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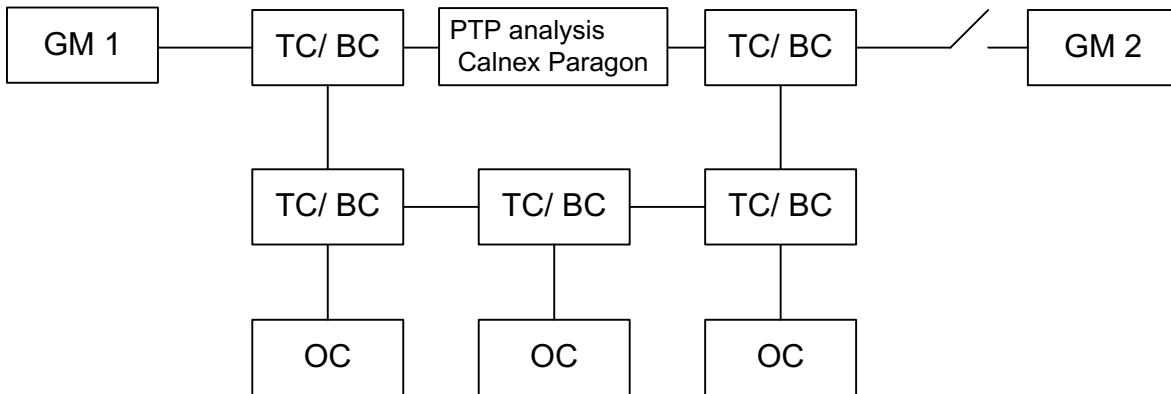
6.5.1 CaR Test A: Recovery in a Ring

Figure 17: Ring with a time offset between GM 1 and GM 2

PROFILES:

- Default [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

- Power Profile configuration **A** [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: **1s**, ANNOUNCE: **1s**, PDELAY: 1s]

- Power Profile configuration **B** [2-step, Multicast Layer 2, P2P Delay Mechanism, SYNC: **8/s**, ANNOUNCE: **4/s**, PDELAY: 1s]

EXPECTED DURATION:

00:07:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups Power Profile configuration **A**
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Start a second GM with a time offset
4	00:07:00	measure how fast / smooth slaves re-establish synchronization with second GM
5	00:08:00	Switch on all slaves either one by one (with a few seconds in between) or in groups Power Profile configuration **B**
6	00:10:00	Check that all slaves selected the GM and synchronized
7	00:12:00	Start a second GM with a time offset
8	00:15:00	measure how fast / smooth slaves re-establish synchronization with second GM

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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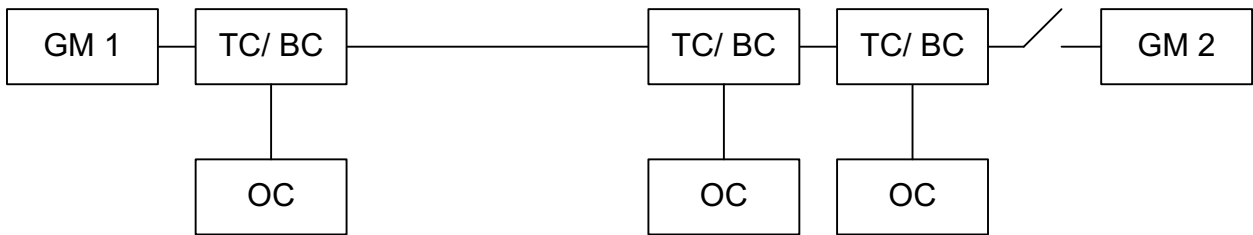## 6.5.2 CaR Test B: Recovery in a Chain

Figure 18: Chain with a time offset between GM 1 and GM 2

PROFILES:

- Telecom [2-step, Unicast Layer 3, E2E Delay Mechanism, SYNC: 1s, ANNOUNCE: 1s, PDELAY: 1s]

EXPECTED DURATION:

00:07:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40).
- GMs have to be set to power profile mode (TLVs) in order to allow Power Profile slaves to accept them
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:03:00	Check that all slaves selected the GM and synchronized
3	00:05:00	Start a second GM with a time offset
4	00:07:00	measure how fast / smooth slaves re-establish synchronization with second GM

EXPECTED TEST RESULTS:

- all slaves should maintain synchronization during the whole test

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.6 TD: Time discontinuities

In these test cases the leap second handling of the slave becomes tested. Further on the slave reaction of the slave by a simulated time jump of one hour into the future and into the past becomes tested.

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6.6.1 TD Test A: Leap Second handling in a Chain

This test checks that Leap Second handling is working correctly. GM clock and what happens during the leap second.
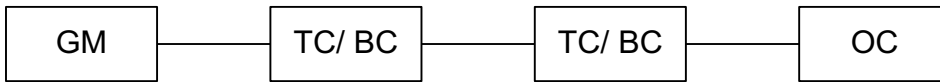

Figure 19: Leap second in the chain

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:05:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM with the lowest priority 1 setting
3	00:03:00	GM Leap Second
6	00:05:00	Check the Leap Second Handling

EXPECTED TEST RESULTS:

- all slaves should handle the Leap Second correctly

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.6.2 TD Test B: Leap Second handling in a Tree

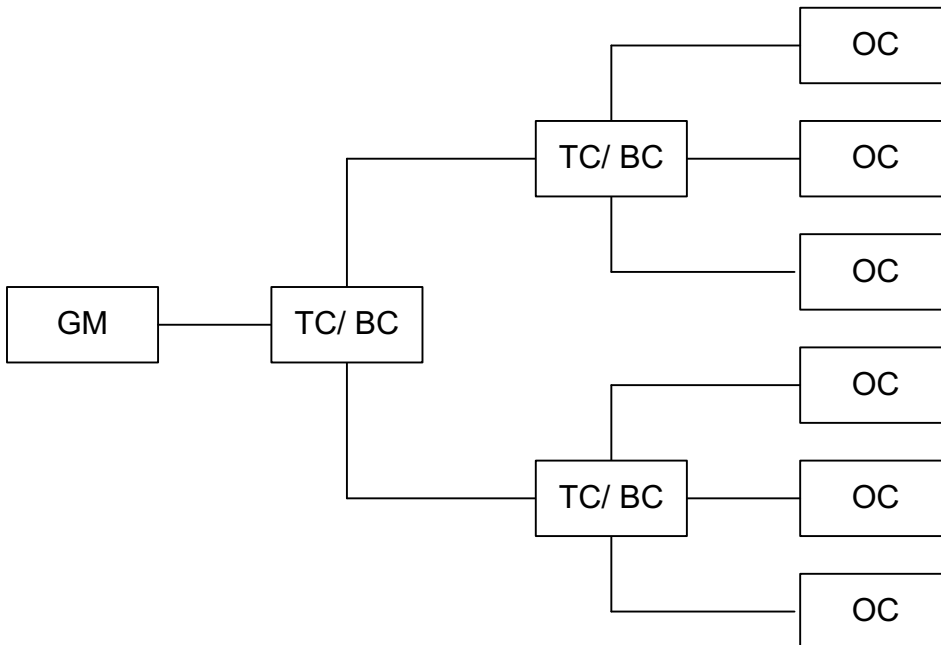This test checks that Leap Second handling is working correctly. GM clock and what happens during the leap second.

Figure 20: Tree with Telecom Profile

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]
- Telecom [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:05:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM with the lowest priority 1 setting
3	00:03:00	GM Leap Second
6	00:05:00	Check the Leap Second Handling

EXPECTED TEST RESULTS:

- all slaves should handle the Leap Second correctly

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.6.3 TD Test C: GM time jump in a Chain

This test checks how the devices handle a GM time jump.
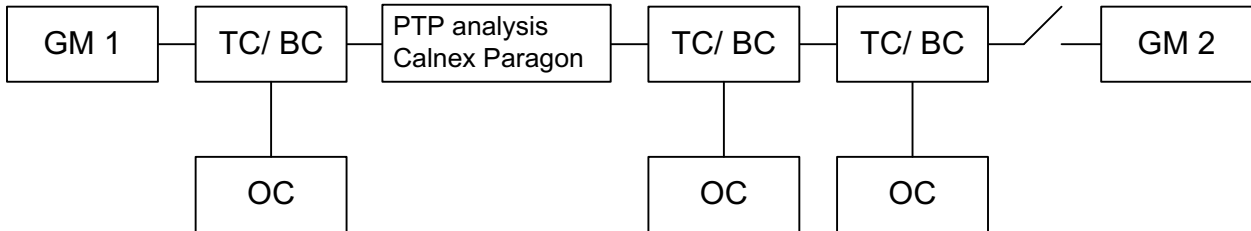

Figure 21: Chain with a time offset of one hour between GM 1 and GM 2

PROFILES:

- Default [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:08:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off and disconnected

TIME JUMP PARAMETERS:

- + 1 hour
- - 1 hour

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TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM with the lowest priority 1 setting.
3	00:03:00	Emulate GM Time Jump of + 1 hour by connecting the GM 2.
6	00:05:00	Check the handling of time jump
3	00:06:00	Emulate GM Time Jump of – 1 hour by disconnecting the GM 2.
6	00:08:00	Check the handling of time jump

EXPECTED TEST RESULTS:

- slaves should handle the time jump without jitter

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)

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6.6.4 TD Test D: GM time jump in a Ring

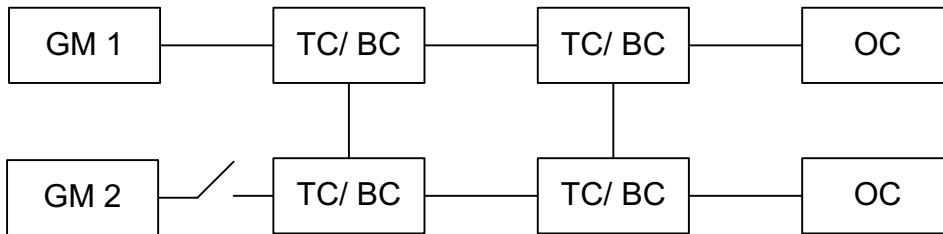This test checks how the devices handle a GM Time jump.

Figure 22: Ring with offset between GM 1 and GM 2

PROFILES:

- Power [2-step, Multicast Layer 3, E2E Delay Mechanism, SYNC: 2s, ANNOUNCE: 2s, DELAY: 8s]

EXPECTED DURATION:

00:08:00

STARTING POINT:

- GM Configuration: Each GM has its own priority1 setting (10, 20, 30, 40)
- Grandmaster Clocks up and running, fully synchronized to GPS
- Slaves powered off / disconnected

TIME JUMP PARAMETERS:

- + 1 hour
- - 1 hour

_____

TEST SEQUENCE:

No.	Elapsed Time	Action
1	00:01:00	Switch on all slaves either one by one (with a few seconds in between) or in groups
2	00:02:00	Check that all slaves selected the GM with the lowest priority 1 setting.
3	00:03:00	Emulate GM Time Jump of + 1 hour by connecting the GM 2.
6	00:05:00	Check the handling of time jump
3	00:06:00	Emulate GM Time Jump of – 1 hour by disconnecting the GM 2.
6	00:08:00	Check the handling of time jump

EXPECTED TEST RESULTS:

- slaves should handle the time jump

TEST MEASUREMENTS:

- PPS measurements of all slaves and GM clocks
- Network traces at grandmaster clocks (switches with port mirroring or Ethernet tap)