3rd mWT Plugtests
Remote
17 – 19 November 2020

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ETSI

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1 Executive Summary

The third Millimetre Wave Transmission (mWT) Plugtests™ event sets a new milestone in a programme of interoperability events for mWT SDN. ETSI, in coordination with the participating organizations, has organized the event in a remote fashion, due to the worldwide restrictions imposed by the COVID-19 pandemic. This event was coordinated and hosted by ETSI, from 17 to 19 of November 2020.

Building on the successful results of the second event, held in July 2020 in a remote fashion, the aim of this third Plugtests event was to expand the trial of SDN solutions for Microwave and Millimetre-wave applications in transport networks. The main goal of the testing activities was to complete the demonstration compliance to the Northbound Interface (NBI) of the SDN Domain Controllers of each participant, connected individually to their respective devices under test. In particular, the test activities focused on the multi-domain configuration and the LLDP tests. Validation of the service definition was performed with a data traffic generator.

The participation was enabled for completely remote solutions, interconnected via HIVE (Hub for Interoperability and Validation at ETSI).

As for the second mWT SDN Plugtests, a key aspect of the tested scenarios was the adoption of a Standard NBI definition based on Restconf and IETF Data Models, including both general network and service level models, and the recently published Microwave Topology Model, to manage service activation and deactivation for mWT domains.

The main highlights of this event are:

1. 100% compliance was achieved, i.e. each participant successfully tested the full set of scenarios in scope; the number of executed tests was increased by 50%;
2. 6 Manufacturers participated, representing a vast majority of the market solutions providers from around the world, including Asia and Europe;
3. 3 Global Telecommunications Operators registered to and followed the preparation of the event;
4. Suitability of this architecture to reduce to zero interoperability testing required among Domains at integration time for real deployments. The Test Cases executed were preparatory to an easier integration process and interoperability levels;
5. Ease and efficiency of converging through active collaboration to a unified and powerful NBI definition;
6. A fully functional (and publicly available) test plan and test suite is produced, as a byproduct of the adopted test architecture, available on the ETSI Forge [i.8].

The results of the Plugtests, and especially the commonly agreed models, will be contributed to ETSI ISG mWT to create a profile of SDN for Microwave and Millimetre-wave transport applications.

2 References

[i.1] I2RS Topology Model: https://tools.ietf.org/html/rfc8345

[i.2] TE Topology Model: https://tools.ietf.org/html/draft-ietf-teas-yang-te-topo

[i.3] MW Topology Model: https://tools.ietf.org/html/draft-ye-ccamp-mw-topo-yang

[i.4] Ethernet Topology Model: https://tools.ietf.org/html/draft-zheng-ccamp-client-topo-yang

[i.5] Ethernet Service Model: https://tools.ietf.org/html/draft-zheng-ccamp-otn-client-signal-yang

[i.6] Restconf protocol: https://tools.ietf.org/html/rfc8040

[i.7] YANG Module Library: https://tools.ietf.org/html/rfc7895

[i.8] FORGE Repository for 2nd mWT SDN Plugtests: https://forge.etsi.org/rep/sdn/mwt/plugtests-2

[i.9] Test Plan: https://portal.etsi.org/Portals/0/TBpages/CTI/Docs/mWT_Plugtests2-3_TestPlan_v1_0.pdf

[i.10] Postman website: https://www.getpostman.com/

[i.11] FORGE Repository for 3st mWT SDN Plugtests: https://forge.etsi.org/rep/sdn/mwt/plugtests-3

3 Abbreviations

DC	Domain Controller
DUT	Device Under Test
GE	Gigabit Ethernet
IFS	Interoperability Feature Statement
mmW	Millimetre wave
MW	Microwave
NBI	Northbound Interface
NE	Network Element
NMS	Network Management System
SBI	Southbound Interface
SDN	Software Defined Network
TD	Test Description

4 Participants

The teams which executed tests during the Plugtest are listed in the table below.

Table 1: List of teams

#	Team
1	Ceragon Networks
2	Ericsson
3	Huawei
4	Intracom Telecom
5	NEC
6	SIAE

Table 2: List of observers

#	Observer

1	BT
2	Deutsche Telekom
3	Vodafone

5 Architecture

5.1 Reference SDN Architecture

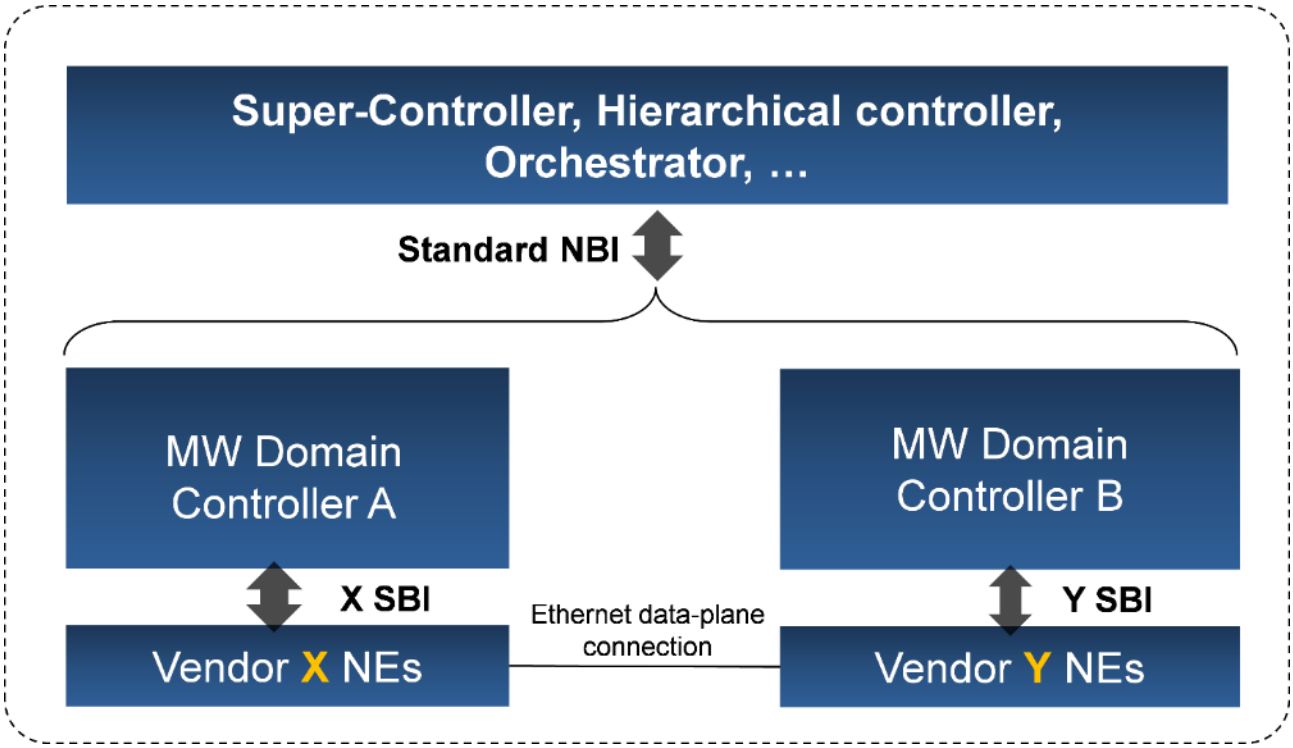

Figure 1 Generic Multi-Domain, Multi-Vendor SDN Architecture

With reference to Figure 1, this Plugtests event kept the focus on the NBI of Domain Controllers (DC), regardless of the specific overall architecture choices made in layers above the Domain Controller itself.

Also, as an explicit choice, nothing was specified or required regarding the DC's SBI (i.e. the interface between a DC and its managed NEs), regarding protocols, data models, etc.

The basis for the definition of the NBI whose compliance was tested by this Plugtests event was the use of the Restconf protocol (RFC 8040 [i.6]) and the YANG Data Model (DM) library provided by IETF (RFCs and relevant drafts [i.7]).

As depicted in Figure 2, in order to simplify the test specification and implementation, the interoperability testing was by unanimous agreement of the participants performed by using an API Development and Testing environment, namely the Postman [i.10] system and its CLI interface, newman.

Tests were performed by exploiting the automation (scripting) capability of *newman*, with a set of scripts being jointly developed specifically for these Plugtests by the Participants and stored in the ETSI Forge code repository, on the basis of the scripts developed for the 2st mWT Plugtests [i.11]. In particular, to test the multi-domain compliancy in a remote

fashion, it was decided to test only the multi-domain services not tested previously during the 2st mWT Plugtests, leaving the domain configuration as single-domain.

Specifying a set of scripts and the expected format and content of the related responses by the DCs, it was possible to univocally determine the compliance of DCs provided by participants to the relevant standards and confirm the single-domain compliance of the systems under test and the specified NBI.

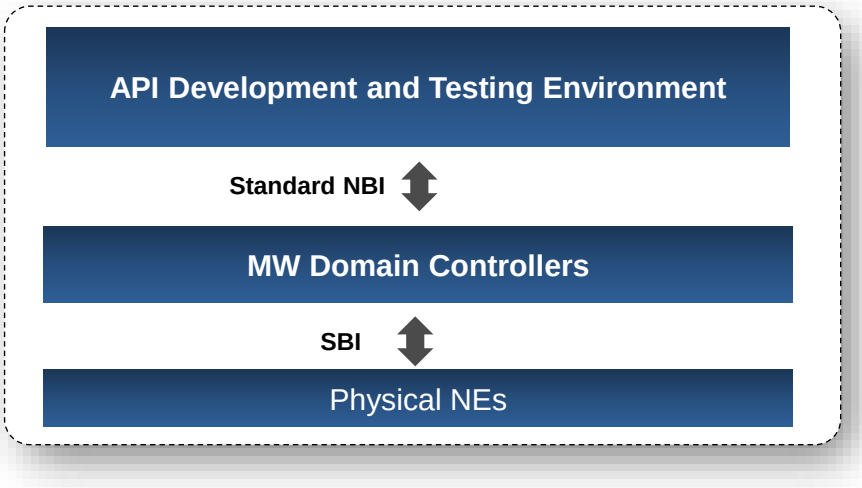

Figure 2 Plugtest SDN Architecture

5.2 Test Network Architecture

The Test Cases were executed against the benches set up on the local lab premises of each participant in a completely remote manner. Remote internetworking was enabled by the HIVE and allowed signaling messages to be exchanged among the ETSI premises (where the test system was deployed) and the remote labs of Plugtests participants. Figure 3 shows a selection of the Test Benches used during the 2nd mWT SND Plugtests. A similar set up has been used by the participants in the 3rd mWT SDN Plugtests during the test sessions.

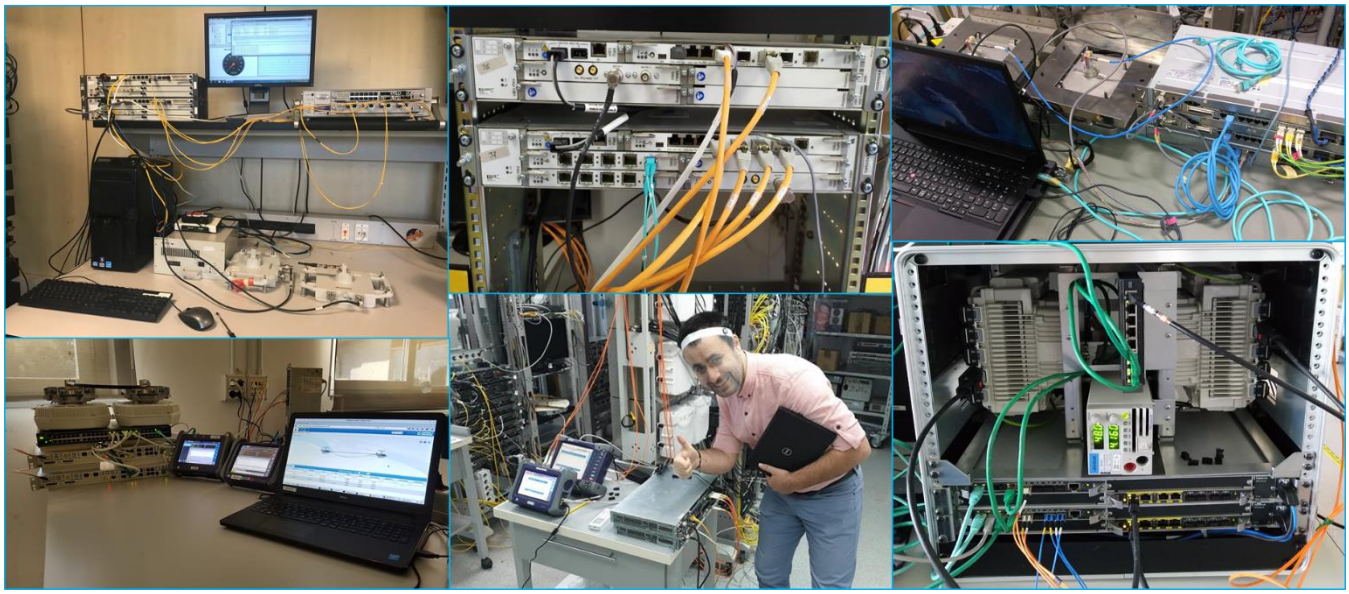

Figure 3 A selection of the Test Benches previously utilized in the 2nd Plugtests. The same set up has been utilized by the participants in the 3rd Plugtests.

5.2.1 Logical Topology

Error! Reference source not found. shows the logical topology of the Plugtests network.

- Each Domain contains exactly one MW (mmW) link. The physical connection between the two RF units of the radio link within one domain shall be realized with coaxial cable or waveguide plus attenuators, no antenna and no free space radiation is allowed;
- The connection between the Domain controller and its MW link is internal to the domain and completely taken care for by the respective Participant;
- All naming of attributes is indexed to the Domain "number" (1 to N for a total of N Domains) in order to simplify the script execution;

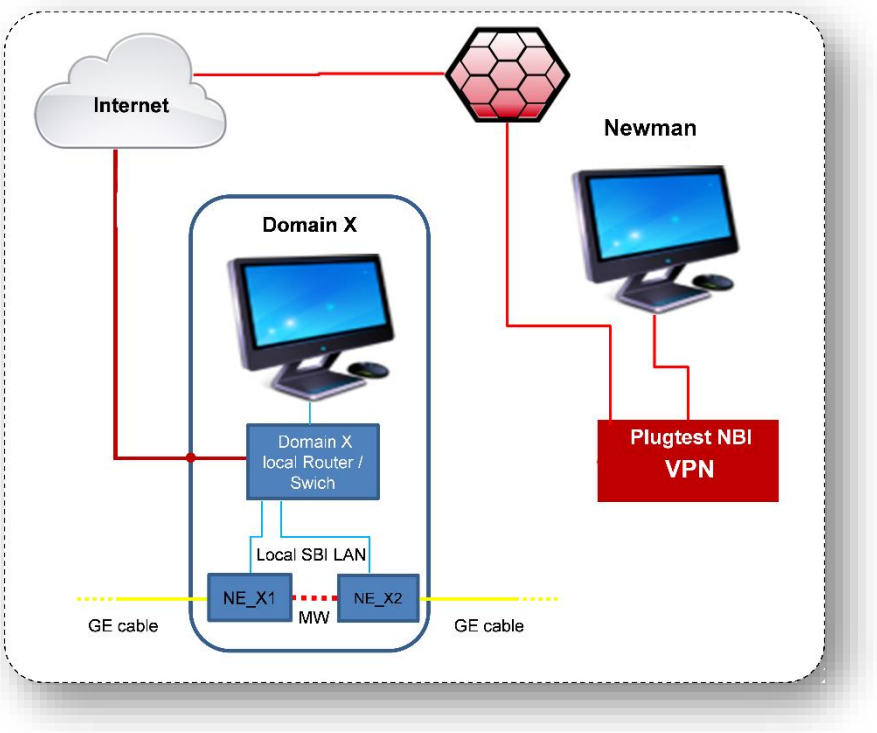

Figure 4 Physical Structure of the Test Network (Detail of one Domain)

- The LAN used to connect the Domain Controllers to the Newman is a Virtual Private Network, enabled via the HIVE;
- Within a test session, the NBI IP addressing plan is static, based on private IP;
- The Domain's own Router / Switch is complete responsibility of the Domain's owner;
- The single Newman instance used for all testing is running on a virtual machine in the HIVE data center, connected via VPN to the NBI LAN;

5.2.2 Data Plane Network

The test cases that create and delete a L2 service required the use of a Test Instrument to generate the traffic, and to confirm that it is flowing correctly withing the indivual Domain. Each participanting organization individually provided such a Test Instrument in its own lab, connected to the respective NEs.

Moreover, to emulate device-to-device inter-connection at the data plane level and provide LLDP tests, a specific workflow was collaboratively designed to allow the exchange of partner specific packet captures. The captured packets were then injected in the connected partner device.

Data Plane network was therefore contained in the remote lab of its organization, and traffic generation and validation was performed on site by the participants, under review of the Plugtests Team and the rest of the participants.

5.3 Data Model Architecture

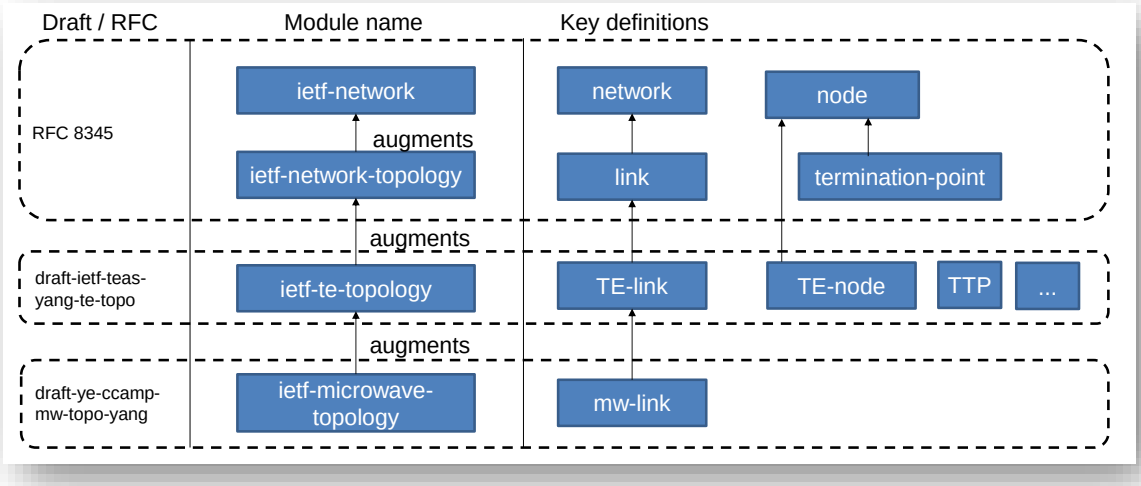

Figure , Figure 6 and Figure depict a simplified DM topology overview as it was used in this Plugtest.

Figure 5 IETF Microwave Topology Models

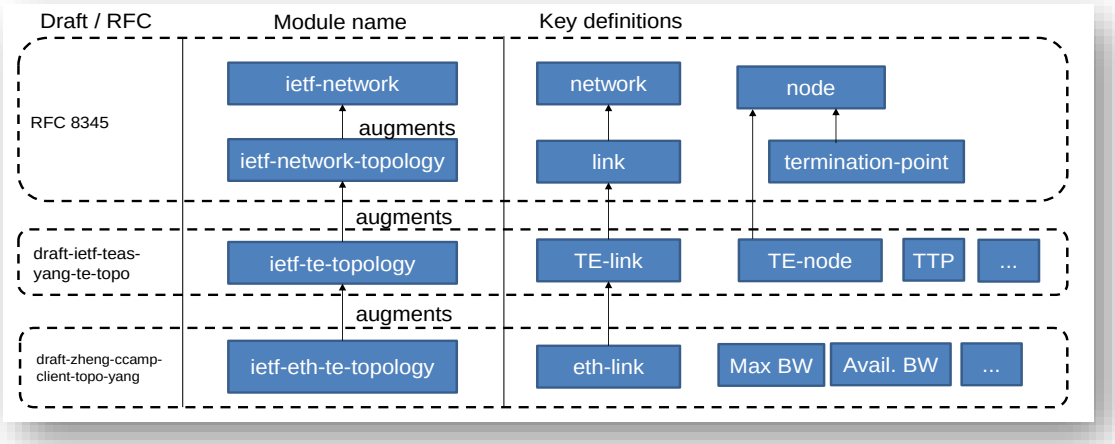

Figure 6 IETF Ethernet Topology Models

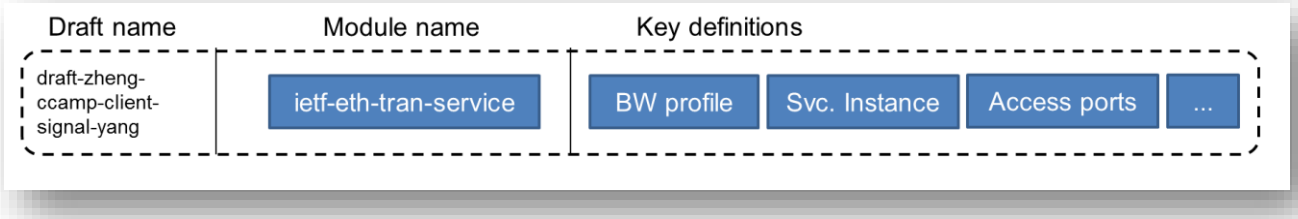

Figure 7 IETF Ethernet Service Model

5.4 Reference Topology Models

5.4.1 Single Domain Topology Exposed on NBI

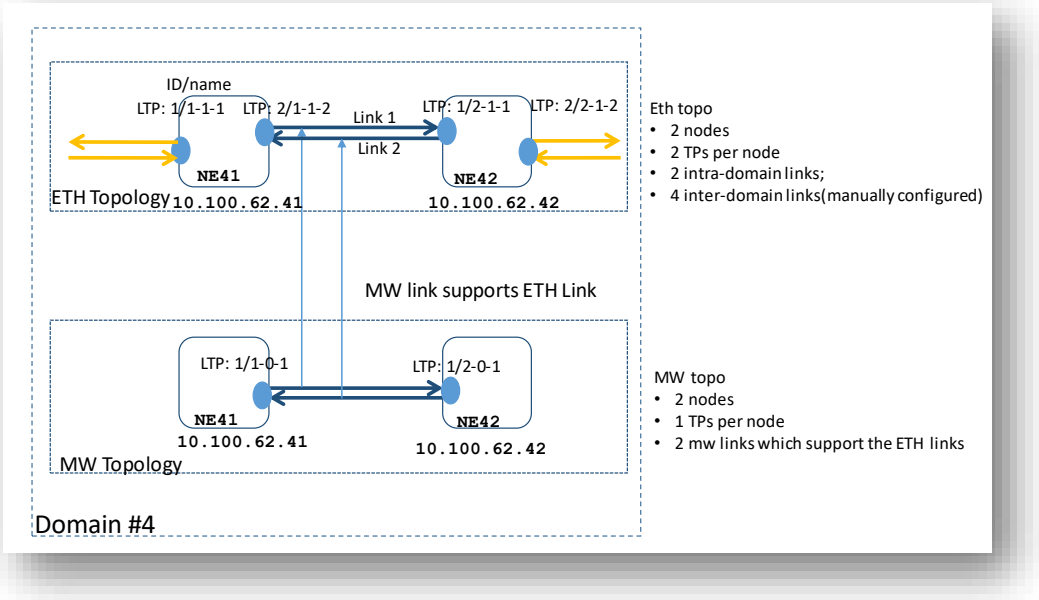

Figure 8 Single Domain Topology Exposed on NBI

Note 1: The inter-domain links' information is not requested to be published across the NBI for this Plugtests.

6 Achieved Compliance Results

The full description of the Test Plan document can be found at [i.9].

In particular, the list of tests executed in the 3rd mWT SDN Plugtests is the following:

1) Discovery tests (TD_SSD_01, TD_SSD_02, TD_SSD_03),
2) Provisioning tests (TD_SSP_01, TD_SSP_02, TD_SSP_03, TD_SSP_04),
3) LLDP tests (TD_LLDP_01), for each pair of participating companies.

The Postman scripts that were used can be found on the ETSI Forge at [i.8]. The scripts are publically available and may be re-used for future testing activities.

```
{
  "info": {
    "_postman_id": "10a2aaa5-bc89-40bb-9eb5-06051f517078",
    "name": "TD_SSP_01",
    "schema": "https://schema.getpostman.com/json/collection/v2.1.0/collection.json"
  },
  "item": [
    {
      "name": "TD_SSP_01-Step-1",
      "event": [
        {
          "listen": "test",
          "script": {
            "id": "950caa88-75b1-429b-8337-4a138ea4fc66",
            "exec": [
              "pm.environment.unset('TD_SDN_RESTCONF_PATH');",
              "var settings = pm.environment.get('TD_SDN_SETTINGS');",
              "var companyName = pm.environment.get('TD_SDN_COMPANY');",
              "var companySettings = settings.companies[companyName];",
```

Figure 9: An example of a scripted test for the NBI, executable with Newman.

The images below represent the the successful result of each individual TD_SSP_01 test, targeting the actual provisioning of the inter-domain L2 services (S1-leaf2 and S2-leaf2). The screenshots report the graphical interface of each participant's traffic generator, showing traffic related to the L2 services activated by the central test system via the NBI under test.

Figure 9 Ceragon TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

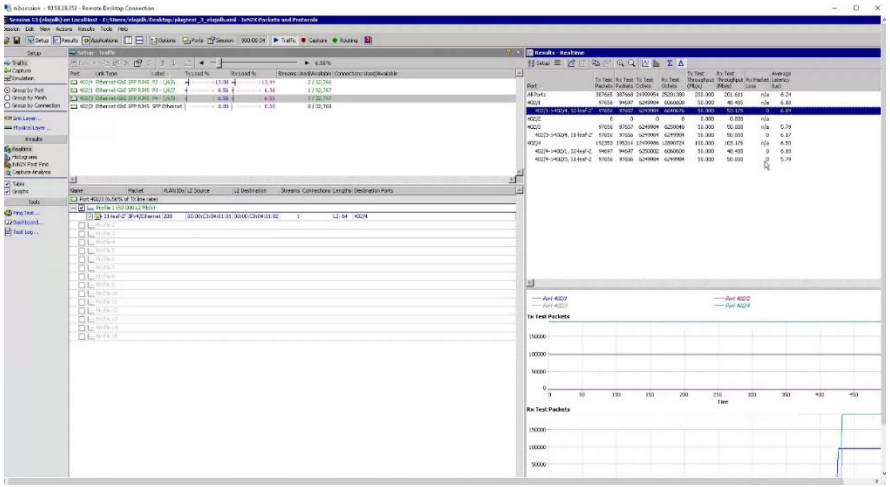

Figure 10 Ericsson TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

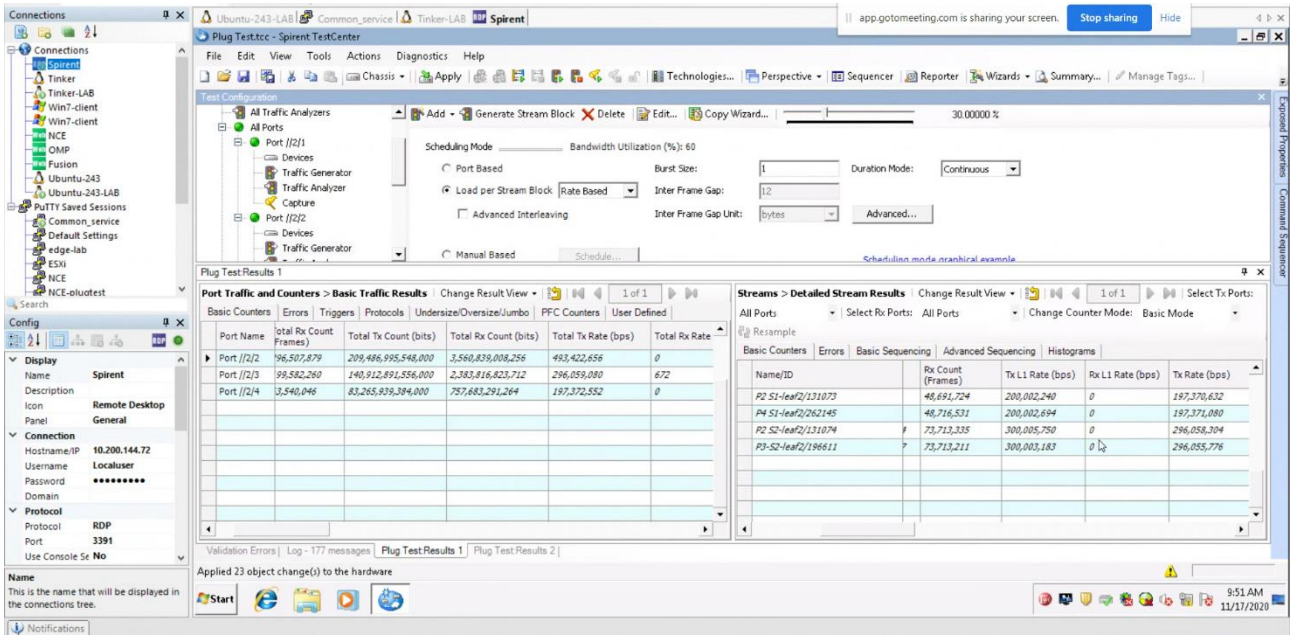

Figure 11 Huawei TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

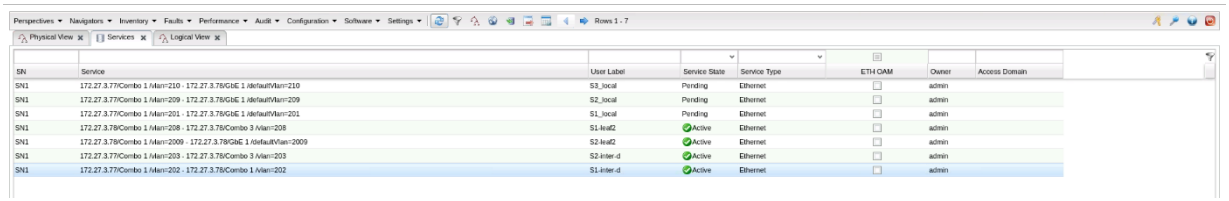

Figure 12 Intracom TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

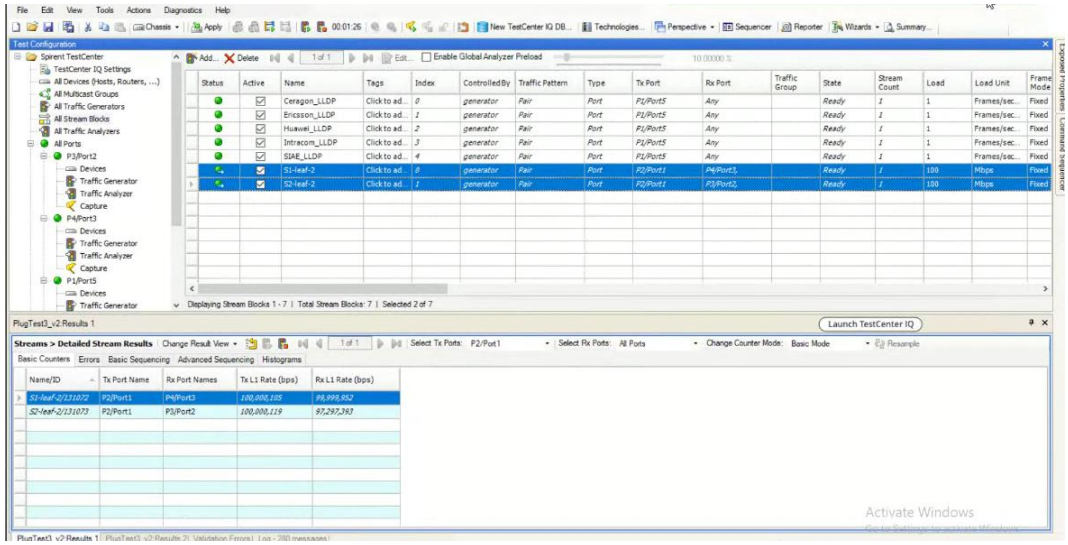

Figure 13 NEC TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

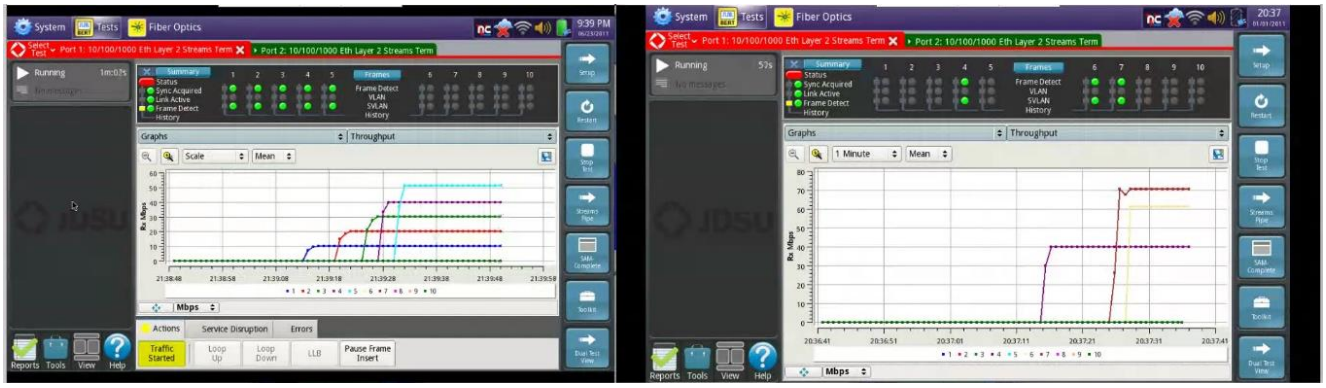

Figure 14 SIAE TD_SSP_01 multi-domain service test (S1-leaf-2 and S2-leaf-2)

The plots of **Error! Reference source not found.** and Figure 16 report the outcomes of each the executed tests.

Error! Reference source not found. shows the outcome statistics collected, grouped by Test Collection. The figure s hows that all the tests executions were successful at least 6 times, one for each participating device under test. Some tests have been executed multiple times because of temporary failures: for discovery (TD_SDD_x) and provisioning (TD_SSP_x) tests five test attempts failed due to temporary miscongurations.

One execution of the LLDP test failed due to an unrecognized LLDP packet sub-type field values. Both temporary issues where resolved and overcome, though reporting the experience may be helpful for future work.

During the event, out of a test plan of 8 test scearios, a total of 78 tests were exectude, among 6 test sessions (one for each participating organization). The scope of the tests was wider than the previous event and the number of executed tests was increased by 50%. The aggregate test outcome results are reported in Figure 16, shows the aggregate test execution pass rate is 92% (including test repetitions) and the aggregate compliance rate is 100%.

At the end of the event, all the tests programmed in the full remote setup were performed successfully.

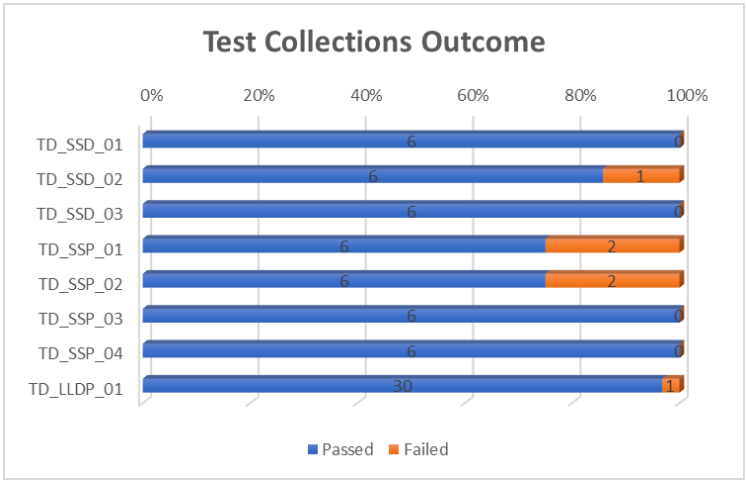

Figure 15 Individual and aggregated results for test case executions.

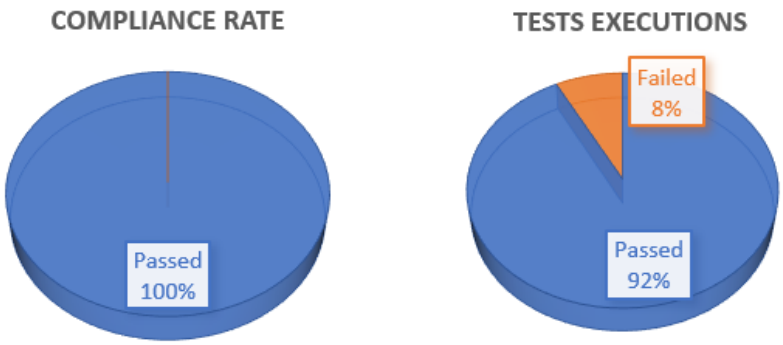

Figure 16 3rd mWT SDN Plugtests aggregated test execution and compliance results.

6.1 Discovery Tests

The results can be found in the accompanying document "3nd_mWT_SDN_Plugtests_Report-Network_Discovery.pdf".

6.2 Service Provisioning Tests

The results can be found in the accompanying document "3nd_mWT_SDN_Plugtests_Report-Service_Provisioning.pdf"".

6.3 LLDP Tests

The results can be found in the accompanying document "3nd_mWT_SDN_Plugtests_Report-LLDP.pdf"". In the document, the results of each vendor-to-vendor test is provided, for a total amount of 30 test outcomes.

7 Lessons Learned

The main novelty introduced in this 3nd event for mWT Interoperability via controller NBI compliance is the definition of common and shared practices to set up L2 services in the realistic deployment types of mWT equipment. This has been resulted in the updataes of the Test Plan[i.9] and consequently in the development of a common set of Postman scripts.

The definition of such services bring the interoperability levels closer to real-life requirements for transport networks.

Other significant lessons learned include:

- The IETF Data Model library provides a very rich set of standards, including micro- / millimetre-wave dedicated models;
- Only a subset of the defined models is needed for the MW/mmW applications;
- It is extremely easy and backward-compatible to extend the standards (now and in the future) to cover specific and new features and applications of MW/mmW;
- Being compliant to common standards, the Domain Controller implementtions are ready for production deployment in real networks;
- Using an API development platform like Postman has many important advantages:

  - It is very easy to quickly converge to a common and compliant implementation of the NBI among different manufacuters by using the very same code and comparing results and behaviours directly. This step took only a few weeks from when the Domain Controllers' implementations were available;
  - There is no ambiguity in describing the expected behaviour for each test case;
  - There is no troubleshooting required in case of behaviour divergence among domains, as there may be by using a third-party "Application";
  - Compliance is determined by the tool itself in a clear Pass/Fail manner;
  - The code developed to be used in the Postman platform turns out to be – as it is – the complete and unified test suite to certify any product for compliance to the NBI definition;
- The ETSI Plugtests™ framework provides a productive, collaborative and fair collaboration environment among different parties across the industry.

8 Conclusions

With respect to initial plans, similarly to the previous event, the Covid-19 Pandemic imposed the remotization of the 3nd mWT Plugtests and required a great organizational effort for the redefinition of the event and the enablement of remote connectivity among implementations of participating organizations.

In particular, the set of applicable test configurations has been focused on completing the multi-domain services connectivity in a single domain configuration and running the LLDP tests. The focus on the tests was centered on compliance of the NBI implementation for Service Discovery and Provisioning and multi-domain LLDP packet inter-operability.

This compliance test campaign resulted in a complete success, of great significance given the almost universal participation of the MW/mmW industry, which is building on the successful results of the mWT SDN Plugtests events.

A clear NBI defined, based on the huge amount of IETF Data Models and protocols and frameworks, allows to quickly achieve complete and provable portability, without need of extensive and extremely resource-intensive prior interoperability testing among any combination of Domain Controller implementations.

This allows not only orders of magnitude for cost savings, but also ensures extreme ease and speed of development and convergence, as was demonstrated that the actual time required to complete all the tests took less time than what was initially planned; instead of 4 testing days, the test campaign could be accomplished within two days.

In conclusion, the 3nd mWT SDN Plugtests, thanks to the great efforts of the participating community to overcome logistics and technological difficulties caused by external factors, set a new step towards higher compliance, portability and interoperability of mWT technologies, demonstrated the possibility and soundness of remote set up for testing which will enable future events to address new challenges and scenarios.

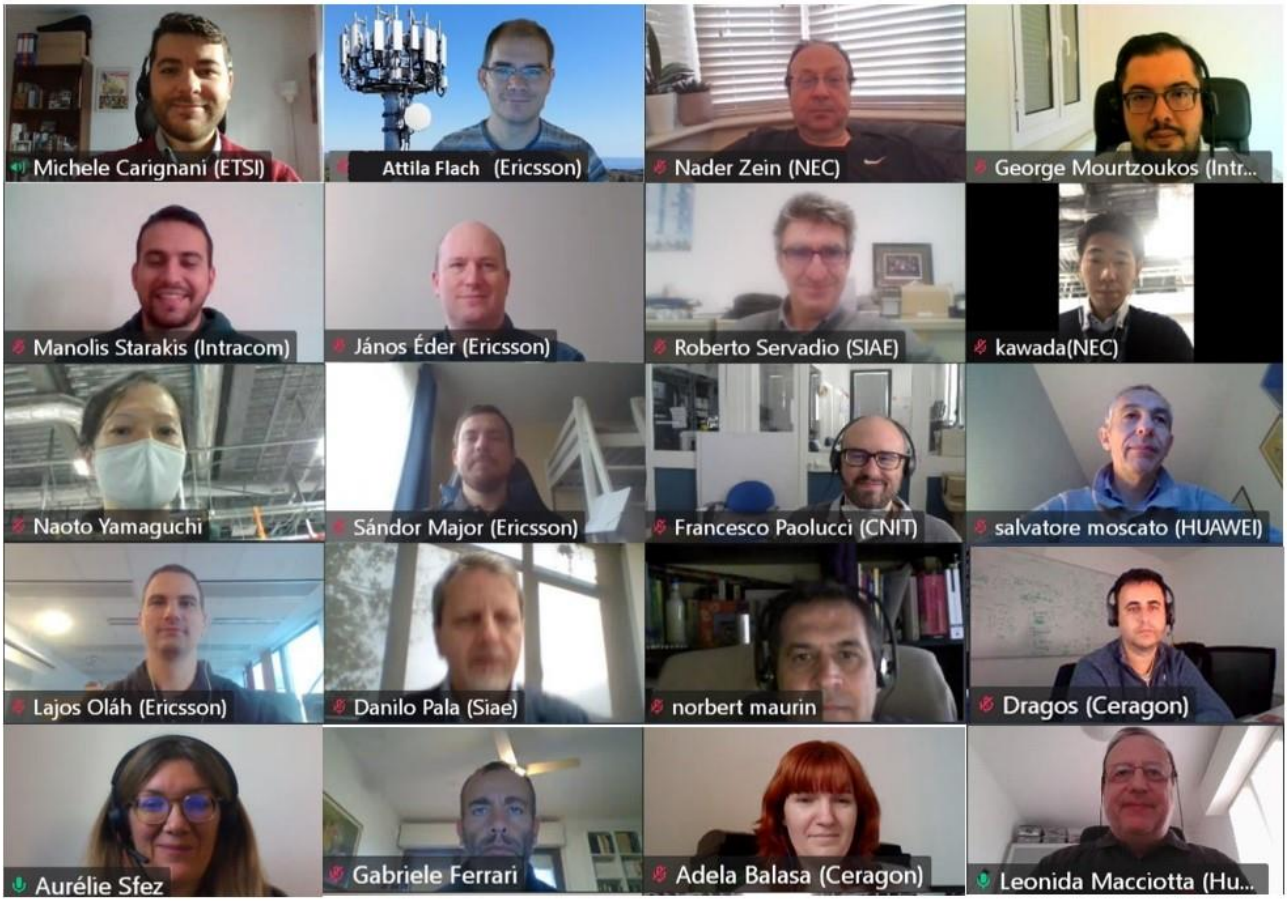

Figure 19: A "virtual" group picture of participants in the Remove mWT Plugtests