Microwave POC overview and demo

Luis M. Contreras

Leganés, October 19th, 2016

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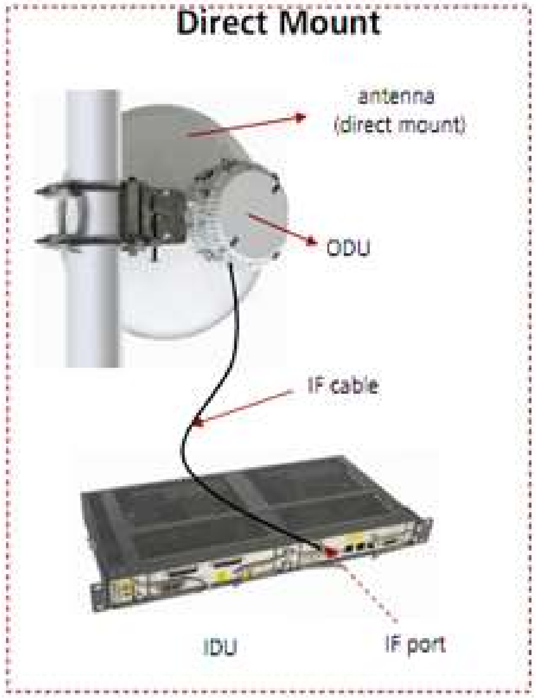
- Motivation and Strategy
- SDN for MW - Proofs of Concept
- ONF Information Model
- Demo
- Conclusions and next steps

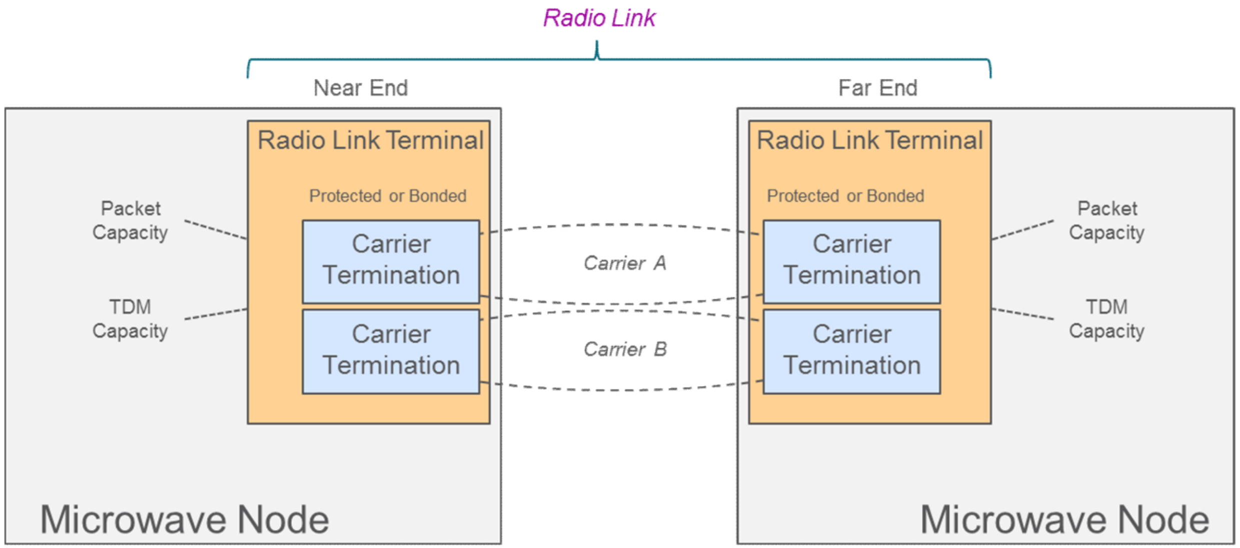
01

Motivation and Strategy

MW nodes


Separate Mount
antenna (separate mount)
Soft waveguide
ODU
IF cable
IDU
IF port


Direct Mount
antenna (direct mount)
ODU
IF cable
IDU
IF port


Radio Link
Near End
Far End
Radio Link Terminal
Protected or Bonded
Packet Capacity
TDM Capacity
Carrier Termination
Carrier Termination
Carrier A
Carrier B
Radio Link Terminal
Protected or Bonded
Carrier Termination
Carrier Termination
Packet Capacity
TDM Capacity
Microwave Node
Microwave Node

Motivation, Framework and Opportunities for applying SDN for MW

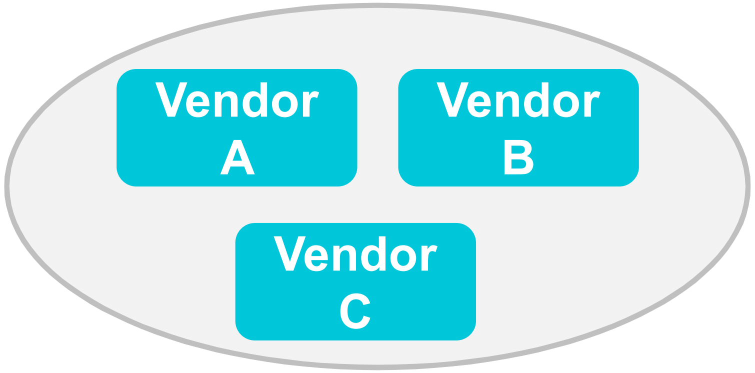
- Motivation
  - ✓ Road to simplification: No common way of controlling and managing Wireless Transport Networks (e.g. Microwaves)
  - ✓ Road to automation: No advanced control plane features for rich functionalities nor multilayer coordination (SDN as an enabler)
- Framework
  - ✓ Work to define a (unified and standard) control plane for Microwave systems
  - ✓ Multi-vendor interworking, multi-layer control, network-wide coordination
- Foreseen Opportunities
  - ✓ Common operation of multi-vendor environments
  - ✓ Innovative Ecosystem for deployment of advanced applications
  - ✓ Multi-technology / Multi-layer coordination
  - ✓ Optimal control of the networks, e.g., adaptation of the MW resources to the real traffic demand

The fundamental change of SDN for MW

- Network **programmability** as the capability of **installing and removing network behavior**, in real time
  - This is not just to populate software line code to simple switches or offering APIs
  - End-to-end network abstraction is required for true technology and vendor integration
- Network **services** to be **realized by programming instead of re-architecting** the network
  - Managing the network in an integrated/coordinated way, not as a collection of individual boxes/layers
  - Stress on service modeling and Information modeling, lately propagated through standard interfaces (Netfconf, Yang, OpenFlow)
- SDN brings MW logic out of the box

The fundamental change of SDN for MW

Proprietary Firmware



- Proprietary OSS
- Proprietary services
- Processing only in the NE

- OPEN Software
- One model for all OB‘s
- Fully disclosed to public
- Applications can be provided by any SW-vendor
- Processing anywhere (centrally or in-the-box)
- Provisioning anywhere

Short model description

- The ONF-model handles radio interface and traffic allocation

Container
e.g. Packet Compression …

Segment Grouping
e.g. Layer 1 Ethernet Link Bundling …

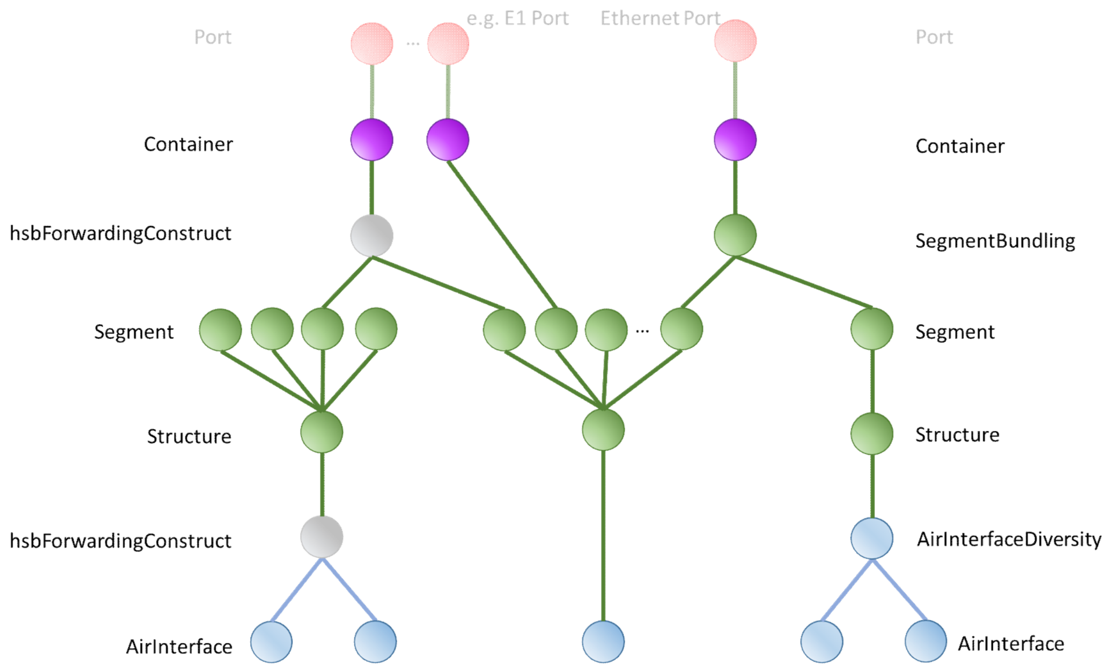
Structure and Segment
e.g. PureEthernet, Hybrid-Microwave, CPRI+Ethernet

Air Interface Grouping
e.g. 1+1 Hot Stand-by, Diversity, XPIC, MIMO …

Air Interface
e.g. Operator specific ID, Frequency, Channel Bandwidth, Adaptive Modulation, ATPC …

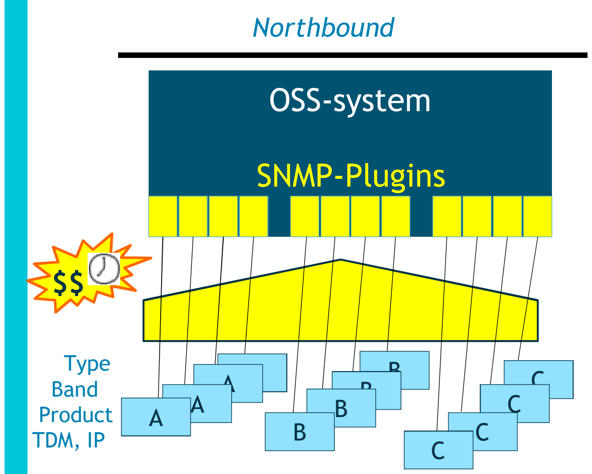
Status and Notification
e.g. Current Modulation, Operational Status …

Performance
ITU-T G.826 and much more about radio air interface



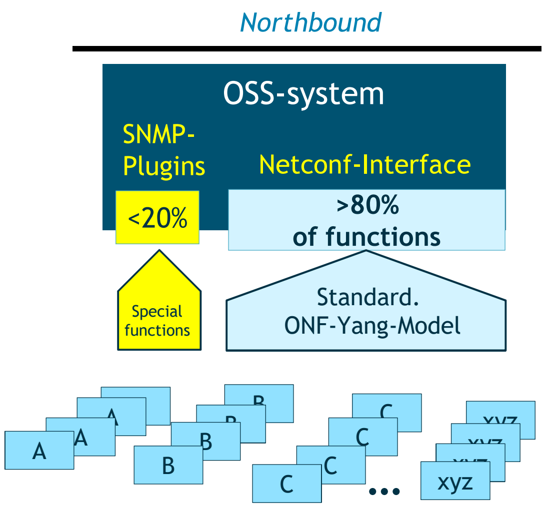
Telefonica Strategy

Current Implementation process



- Every new MW-type requires a new implementation (software plugin) in the OSS-system
  - Invest for each new type
  - Implementation time

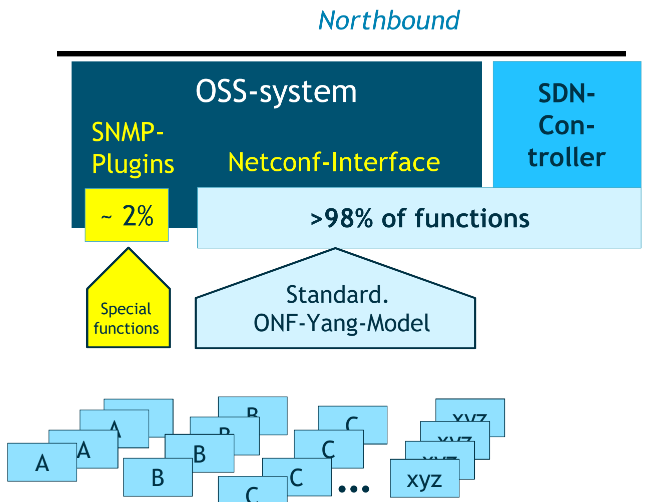
Step 1



- ONE Netconf-Southbound-Interface for all standard MW-functions
- Special functions with small SNMP-plugins

MW-vendors compliant with ONF-Model

Step 2

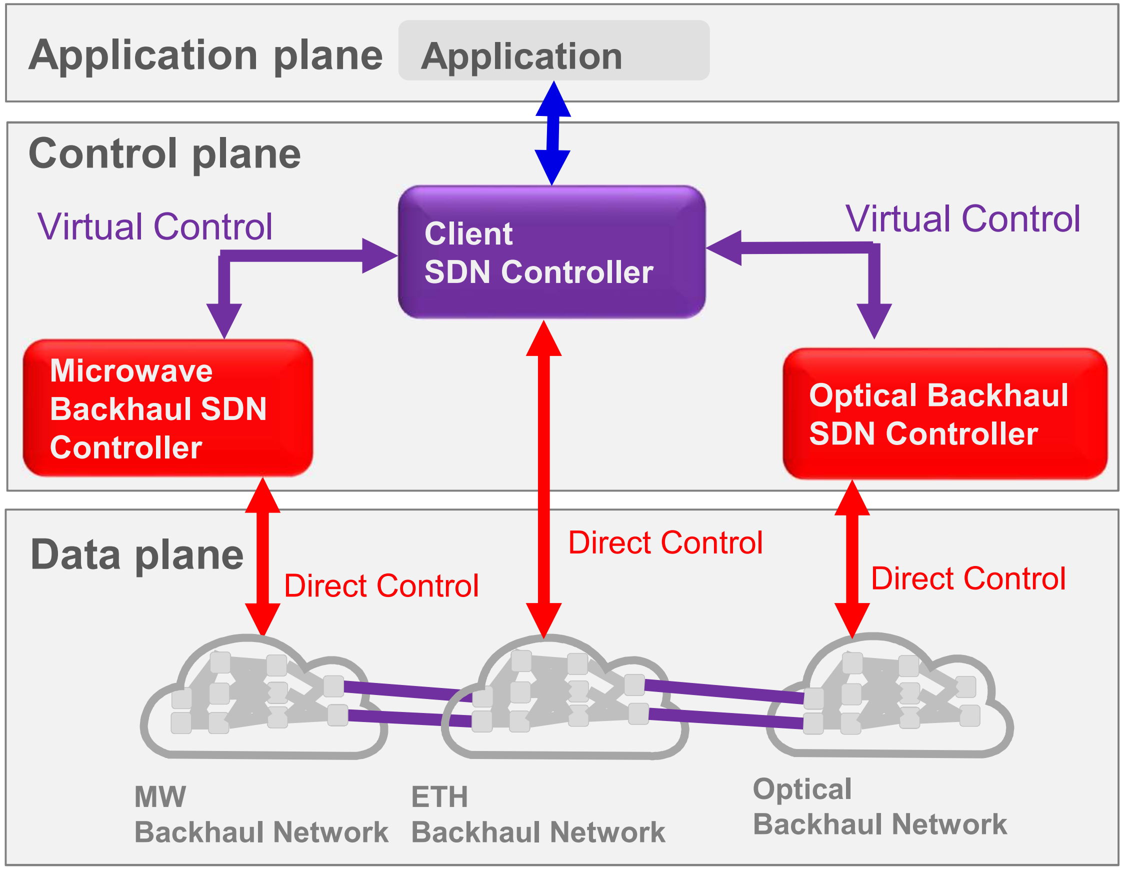


- ONF-Model is connected to a SDN controller with Northbound Interface
- Same provisioning of all standard functions independent from Vendor, Frequency band and product
- Only special functions via SNMP plugins to Northbound

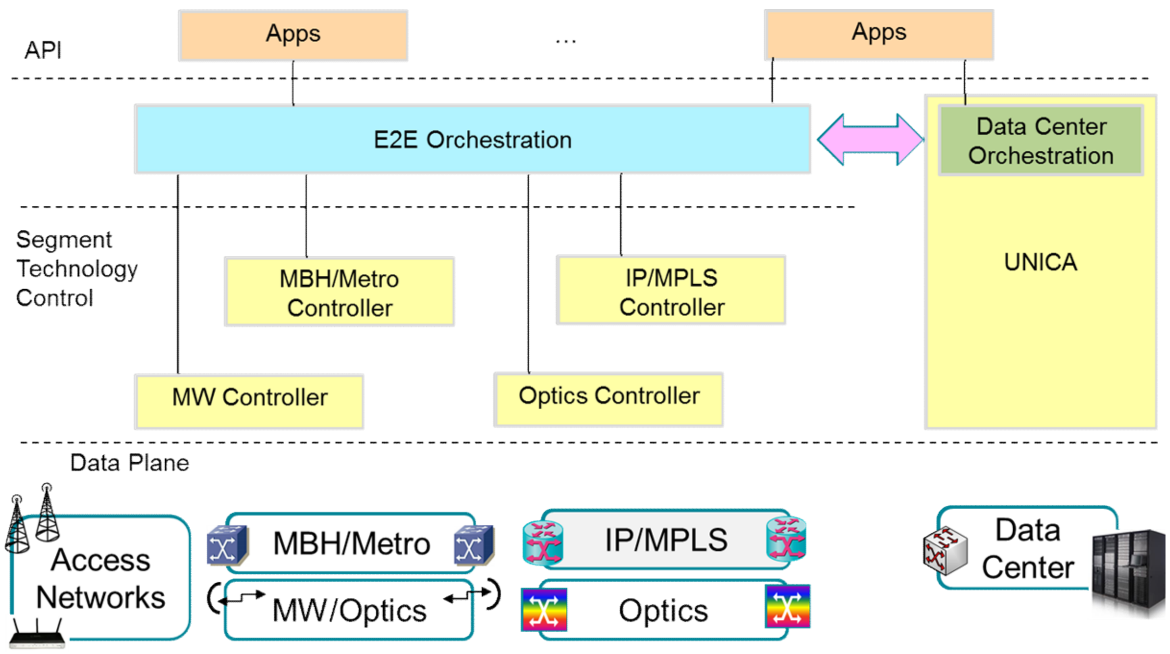
Mid-term target - Mobile Backhaul

- Separate, independent layers do not allow overall optimization
  - Multilayer approach for performing combined optimization
- Separated domains complicate the service provisioning and network adaptation
  - Interconnection of controllers for e2e optimization
- Separated control and management mechanisms require multiple interventions
  - Standard interfaces simplify heterogeneous device management

SDN control will allow the orchestration of the network resources



E2E SDN Orchestration



- Network and Systems decoupling
- Multivendor systems interoperability
- Network domains (MW, Metro-IP) combining network elements from different vendors

What is needed?

- Common SBI per technology for MW, Metro/MBH and IP. Mediation layer
- Common SDN controller per technology. Mediation layer in first deployments while a common SBI is defined.
- Standard NBI between towards current systems and controllers

02

SDN for MW - Proofs of Concept

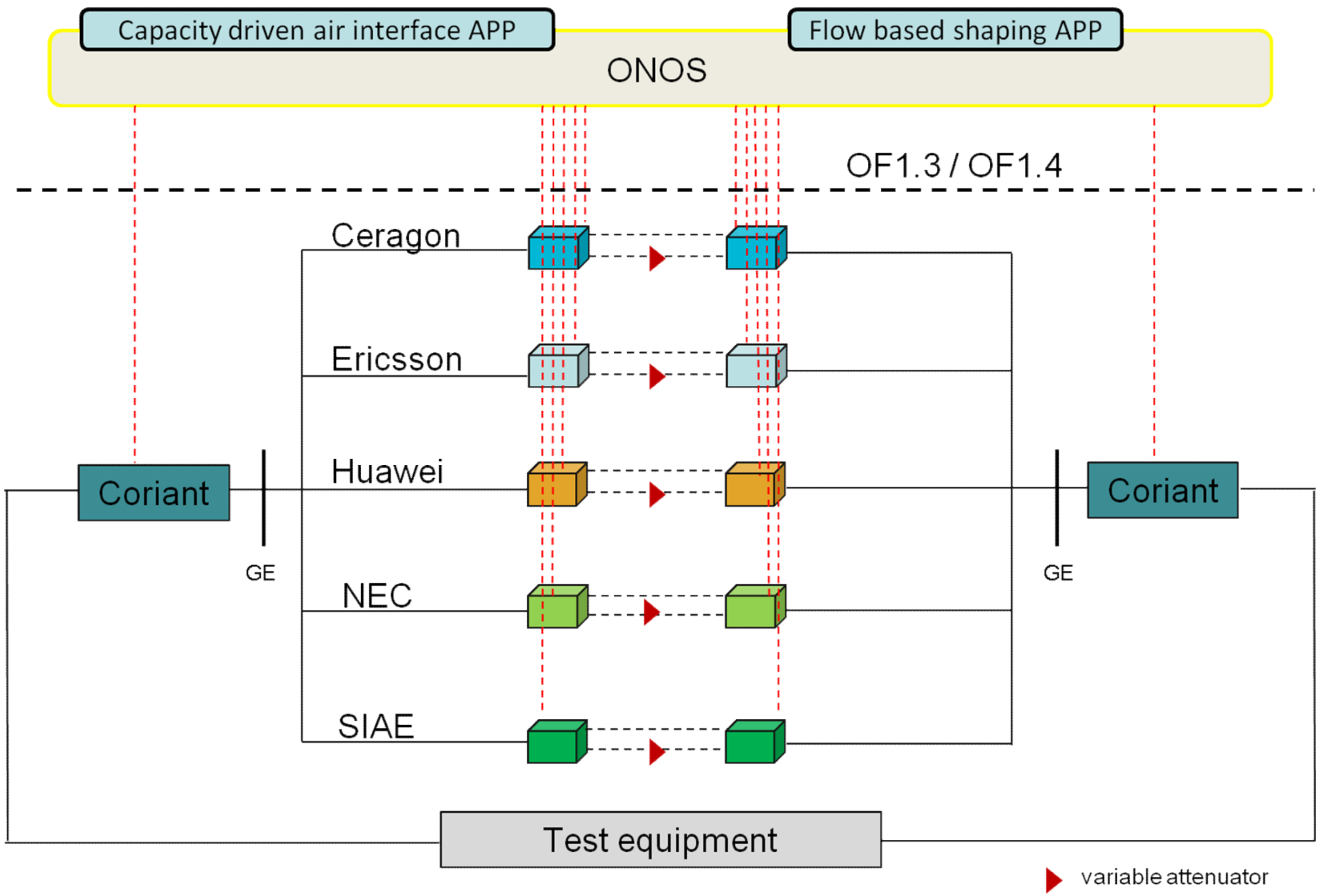
History of the PoCs

- First PoC held on October 2015, Madrid, organized by Telefonica
    - Focus on validating the concept of SDN for MW
    - Usage of OpenFlow and ONOS
- Second PoC held on April 2016, Munich, organized by Telefonica
    - Focus on validating Information Model suitability and Operational use cases
    - Usage of Netconf and OpenDayLight
- Third PoC to be hold on October 2016, US, organized by AT&T
    - Focus on completing the full implementation of the Information Model
- Fourth PoC foreseen for Q2 2017, organization and scope to be defined

First PoC Use Cases

- Capacity driven air interface
  - ✓ It shows how the SDN controller optimizes the total power consumption in a wireless transport network
  - ✓ The controller disables underlying physical ports of wireless L1 LAG links when the utilization is below certain thresholds
    - The controller MUTE or UNMUTE physical ports (OFPWTIPPT_TX_MUTE)
- Flow basing shaping
  - ✓ Control of both wireless transport and switching equipment from the same SDN controller
  - ✓ The controller enables/disables policer on the router according to the observed wireless link capacity and some defined thresholds (OFPWTIPPT_TX_CURRENT_CAPACITY)

First PoC High Level Setup



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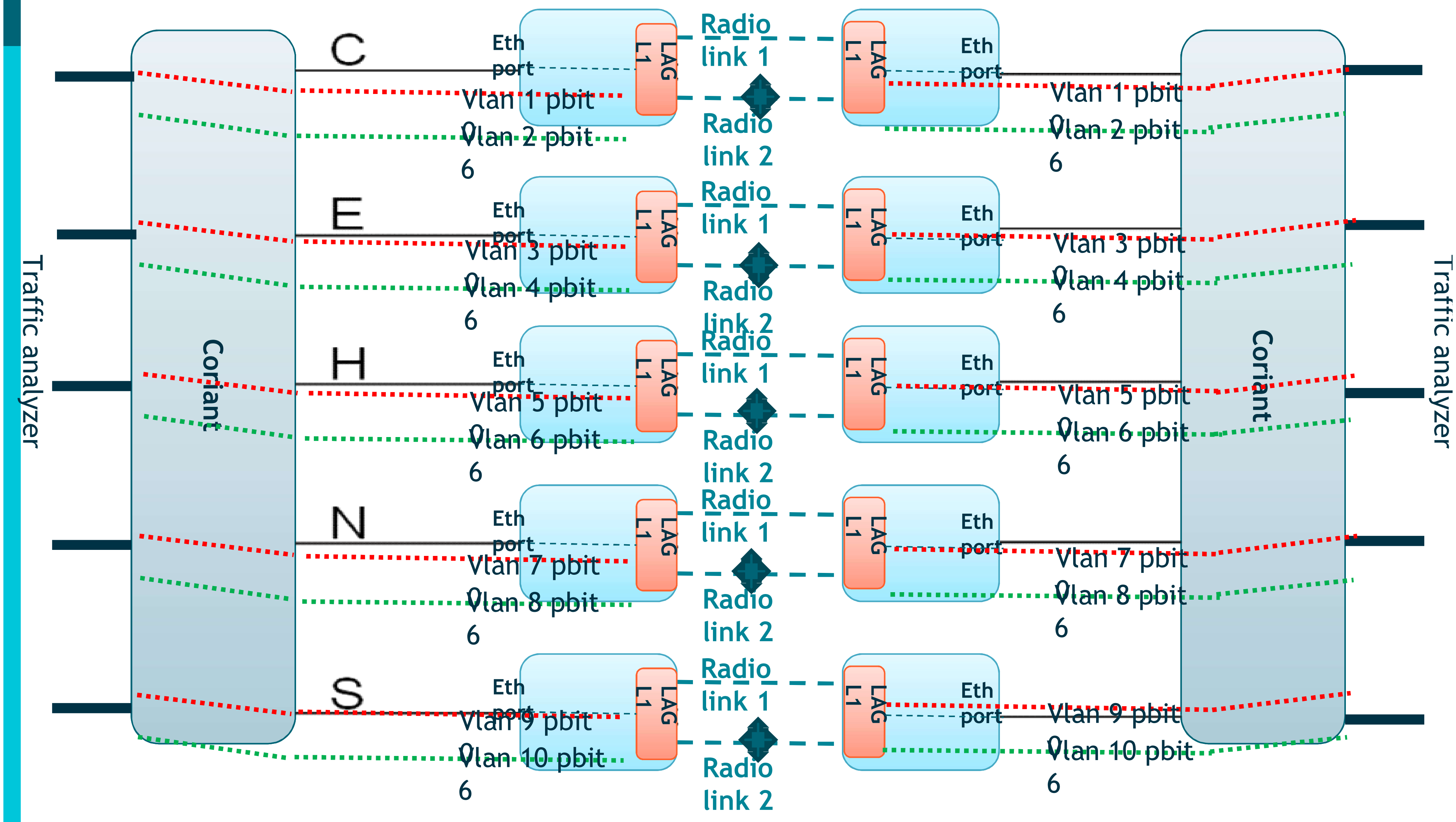
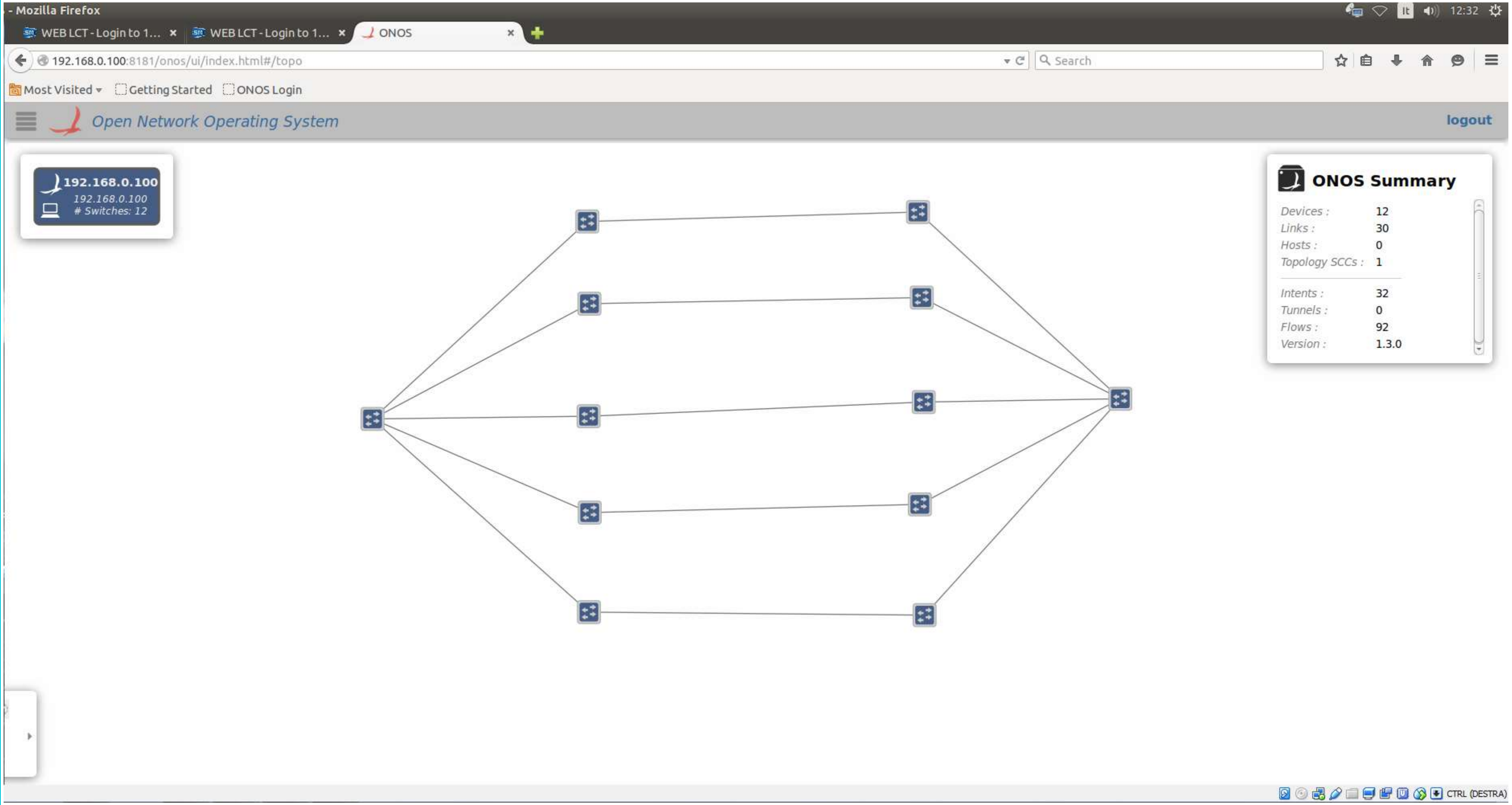
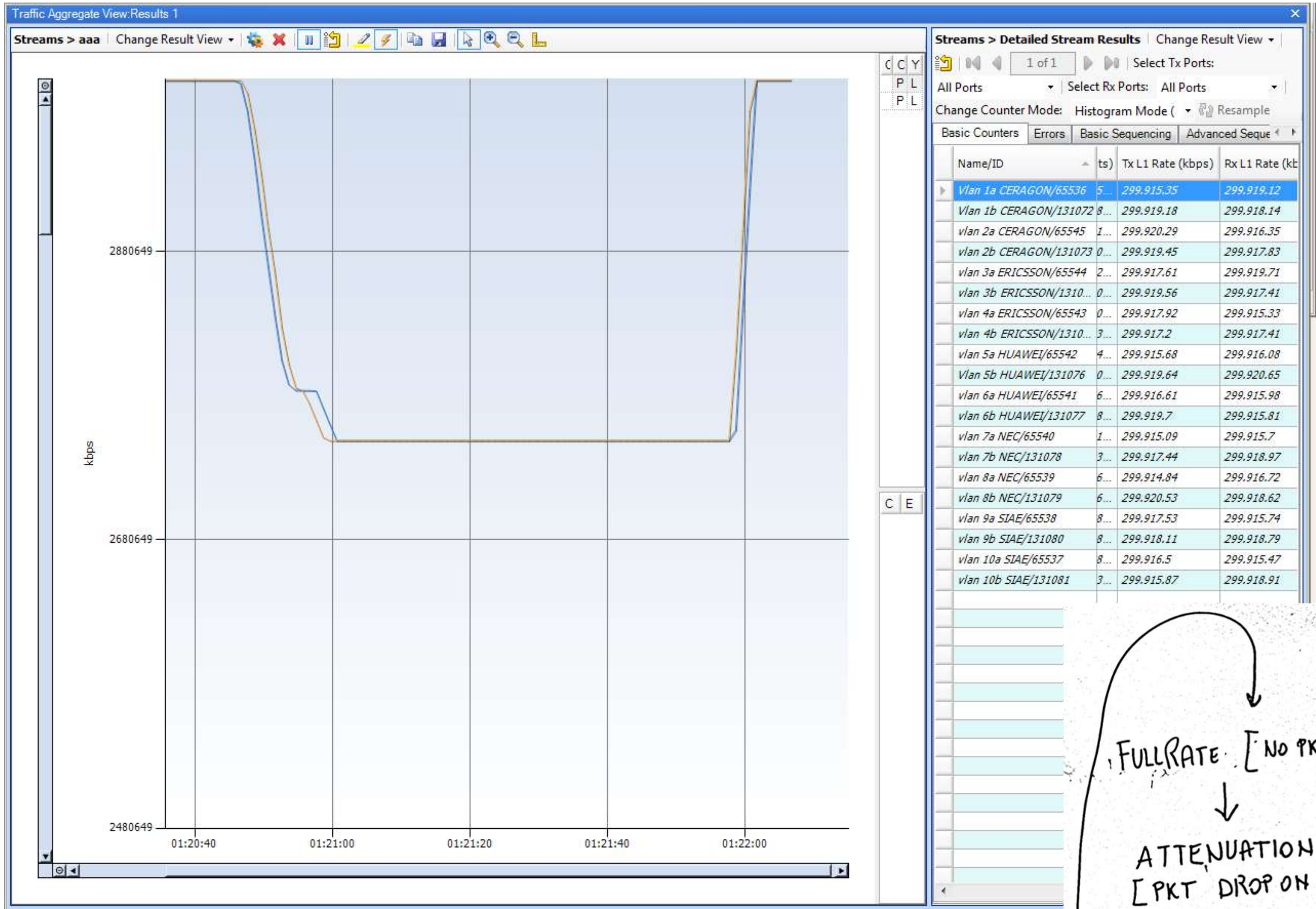
First PoC Low Level Setup



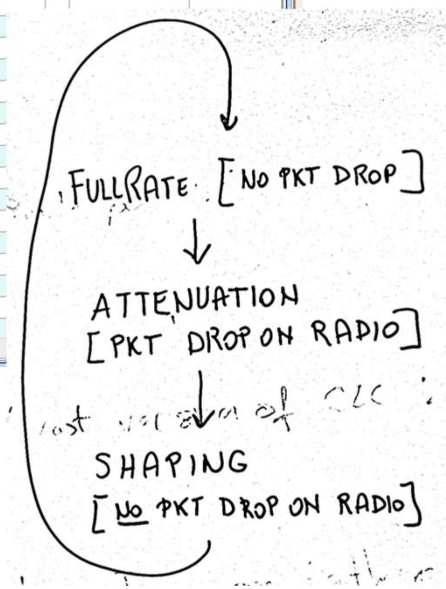
Topology representation



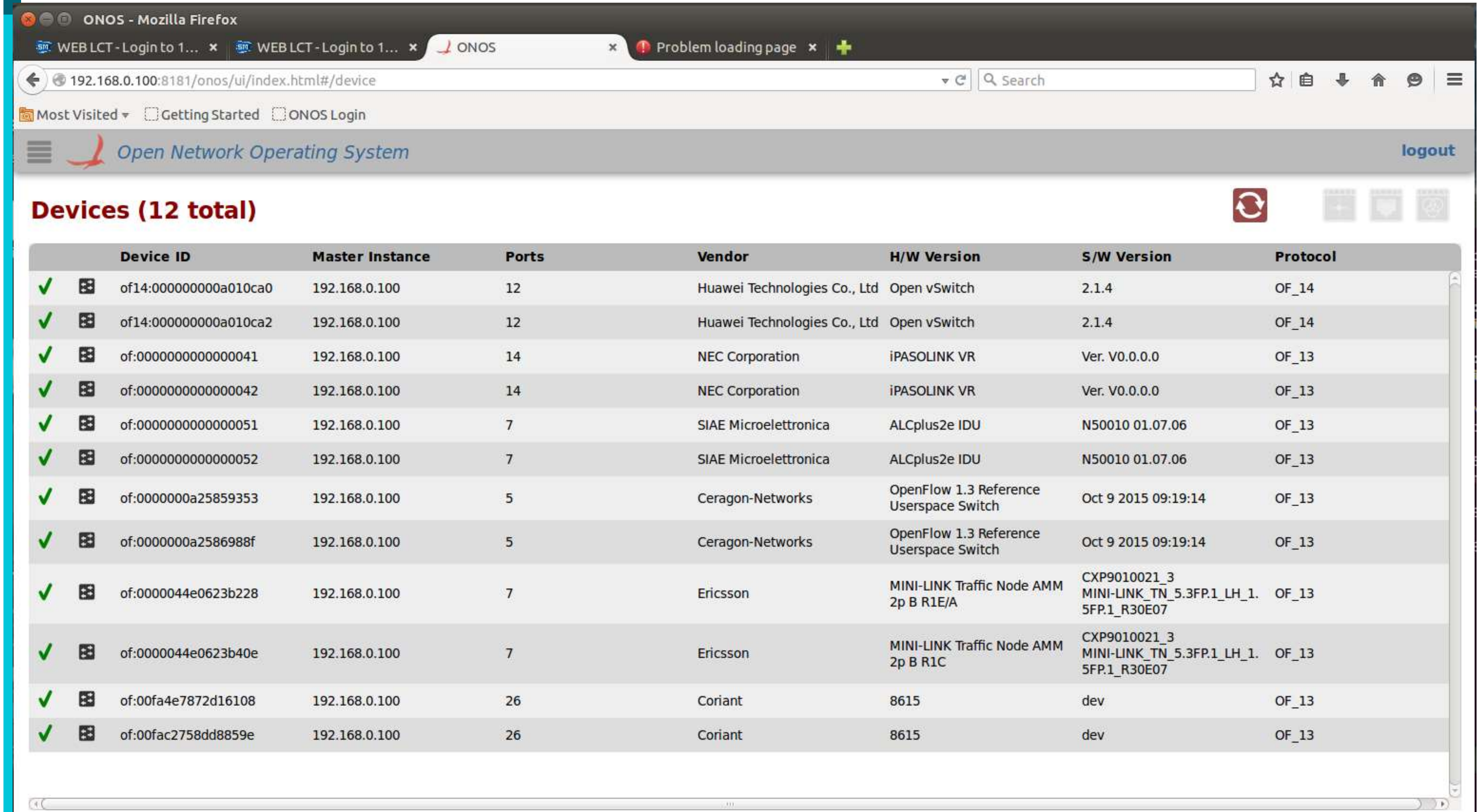
Traffic shaping



Name/ID	ts)	Tx L1 Rate (kbps)	Rx L1 Rate (kb
Vlan 1a CERAGON/65536	5...	299.915.35	299.919.12
Vlan 1b CERAGON/131072	8...	299.919.18	299.918.14
vlan 2a CERAGON/65545	1...	299.920.29	299.916.35
vlan 2b CERAGON/131073	0...	299.919.45	299.917.83
vlan 3a ERICSSON/65544	2...	299.917.61	299.919.71
vlan 3b ERICSSON/1310...	0...	299.919.56	299.917.41
vlan 4a ERICSSON/65543	0...	299.917.92	299.915.33
vlan 4b ERICSSON/1310...	3...	299.917.2	299.917.41
vlan 5a HUAWEI/65542	4...	299.915.68	299.916.08
Vlan 5b HUAWEI/131076	0...	299.919.64	299.920.65
vlan 6a HUAWEI/65541	6...	299.916.61	299.915.98
vlan 6b HUAWEI/131077	8...	299.919.7	299.915.81
vlan 7a NEC/65540	1...	299.915.09	299.915.7
vlan 7b NEC/131078	3...	299.917.44	299.918.97
vlan 8a NEC/65539	6...	299.914.84	299.916.72
vlan 8b NEC/131079	6...	299.920.53	299.918.62
vlan 9a SIAE/65538	8...	299.917.53	299.915.74
vlan 9b SIAE/131080	8...	299.918.11	299.918.79
vlan 10a SIAE/65537	8...	299.916.5	299.915.47
vlan 10b SIAE/131081	3...	299.915.87	299.918.91



Inventory of Devices in the Controller



Device ID	Master Instance	Ports	Vendor	H/W Version	S/W Version	Protocol
of14:000000000a010ca0	192.168.0.100	12	Huawei Technologies Co., Ltd	Open vSwitch	2.1.4	OF_14
of14:000000000a010ca2	192.168.0.100	12	Huawei Technologies Co., Ltd	Open vSwitch	2.1.4	OF_14
of:0000000000000041	192.168.0.100	14	NEC Corporation	iPASOLINK VR	Ver. V0.0.0.0	OF_13
of:0000000000000042	192.168.0.100	14	NEC Corporation	iPASOLINK VR	Ver. V0.0.0.0	OF_13
of:0000000000000051	192.168.0.100	7	SIAE Microelettronica	ALCplus2e IDU	N50010 01.07.06	OF_13
of:0000000000000052	192.168.0.100	7	SIAE Microelettronica	ALCplus2e IDU	N50010 01.07.06	OF_13
of:0000000a25859353	192.168.0.100	5	Ceragon-Networks	OpenFlow 1.3 Reference Userspace Switch	Oct 9 2015 09:19:14	OF_13
of:0000000a2586988f	192.168.0.100	5	Ceragon-Networks	OpenFlow 1.3 Reference Userspace Switch	Oct 9 2015 09:19:14	OF_13
of:0000044e0623b228	192.168.0.100	7	Ericsson	MINI-LINK Traffic Node AMM 2p B R1E/A	CXP9010021_3 MINI-LINK_TN_5.3FP.1_LH_1. 5FP.1_R30E07	OF_13
of:0000044e0623b40e	192.168.0.100	7	Ericsson	MINI-LINK Traffic Node AMM 2p B R1C	CXP9010021_3 MINI-LINK_TN_5.3FP.1_LH_1. 5FP.1_R30E07	OF_13
of:00fa4e7872d16108	192.168.0.100	26	Coriant	8615	dev	OF_13
of:00fac2758dd8859e	192.168.0.100	26	Coriant	8615	dev	OF_13

First PoC team

Vendors

CERAGON

Coriant

ERICSSON

HUAWEI

NEC

SM
siae microelettronica

Controller

onos
Open Network Operating System

Standardization

ONF

Organization and support

Telefónica

institute IMDEA networks

5TONIC

Universidad Carlos III de Madrid

First PoC outcomes

OPEN NETWORKING FOUNDATION

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Press Releases

Open Networking Foundation Completes Industry's First Wireless Transport SDN Proof of Concept

Member Companies Test Open SDN PoC Developed by ONF-sponsored OpenSourceSDN.org Community

SDN AND OPENFLOW WORLD CONGRESS, Düsseldorf, Germany, October 13, 2015 – The Open Networking Foundation (ONF), a non-profit organization dedicated to accelerating the adoption of open Software-Defined Networking (SDN), has completed the industry's first multi-vendor Wireless Transport SDN Proof of Concept (PoC). Furthering ONF's goal of promoting greater commercial adoption of SDN, the PoC was designed to encourage the development, testing, and implementation of open SDN for Wireless Transport and to demonstrate multi-layer optimization on an open SDN infrastructure. This PoC originated in ONF's Open Transport Working Group and evolved from a specification into an open source software project in the OpenSourceSDN.org community that ONF sponsors and that is open to the public.

ONF member companies Ceragon Networks, Coriant, Ericsson, Huawei, NEC and SM Optics (SIAE MICROELETTRONICA group)participated in the PoC testing, held October 7-9, 2015 in Madrid. Participating member companies provided the networking equipment and software consistent with the SDN architecture and leveraged the Open Network Operating System (ONOS) open source SDN controller. Testing was hosted by Telefónica and IMDEA Networks Institute, with support from Universidad Carlos III de Madrid.

ONF Press release
https://www.opennetworking.org/news-and-events/press-releases/2572-open-networking-foundation-completes-industry-s-first-wireless-transport-sdn-proof-of-concept

PoC Video
https://youtu.be/1Y3MeGLANJ4

OPEN NETWORKING FOUNDATION

Wireless Transport SDN
Proof of Concept White Paper

V1.0
2015-10-09

Wireless Transport SDN PoC White Paper
https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/ONF_Microwave_SDN_PoC_White_Paper%20v1.0.pdf

ONOS Applications

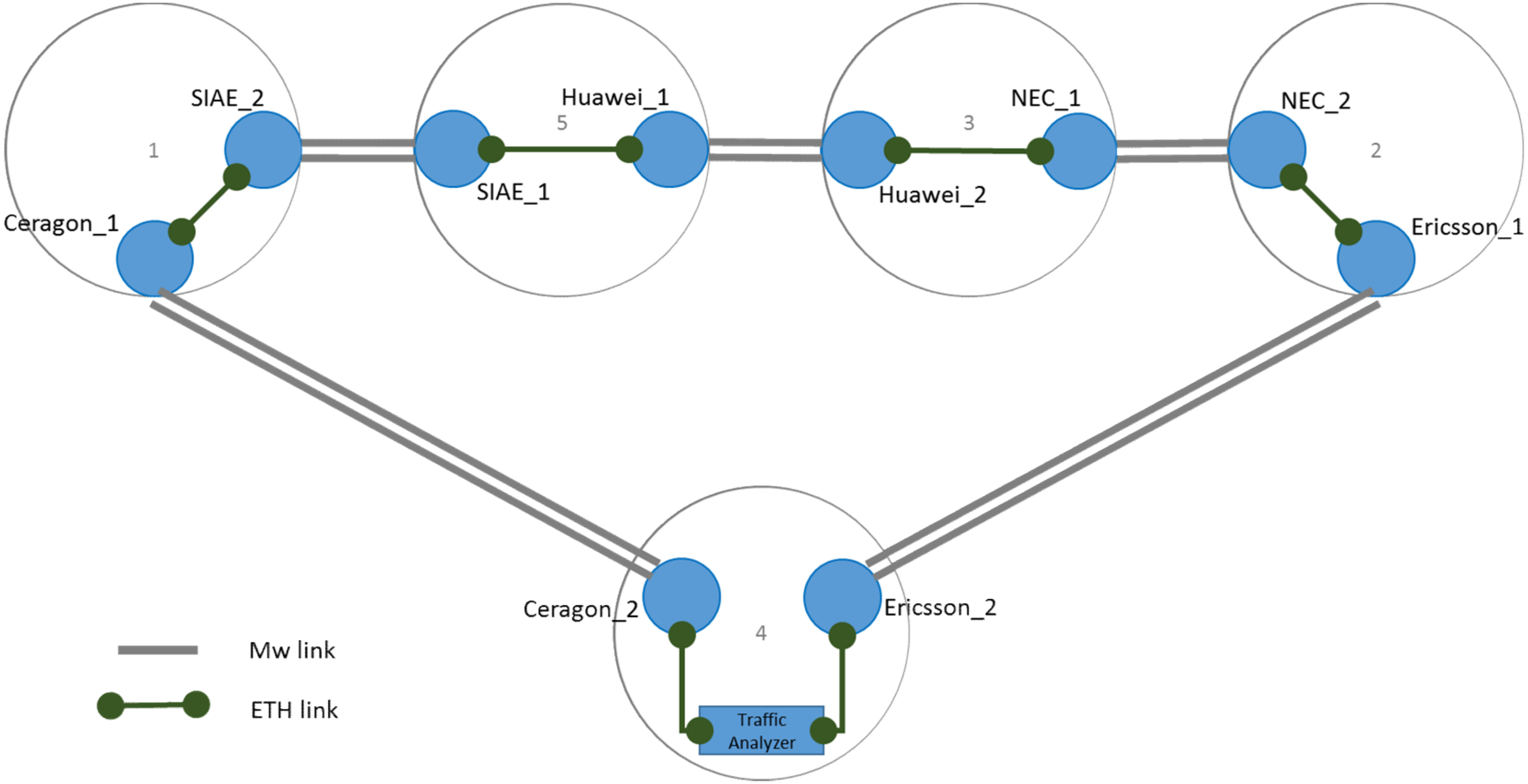
From First PoC to Second PoC

- **Extending the MW information model** to cover a broader set of attributes (e.g. configuration, events, performance information)
- **Aligning** the microwave model **with the ONF core information model**
- Moving the focus from OpenFlow to **Netconf/YANG**, which is much **better in handling information models**
- Moving from ONOS to **OpenDaylight**, since we needed **to develop a flexible and open MW NBI**
- Focusing on **re-usable applications**
- **Upstream all code and applications** to be used by the community

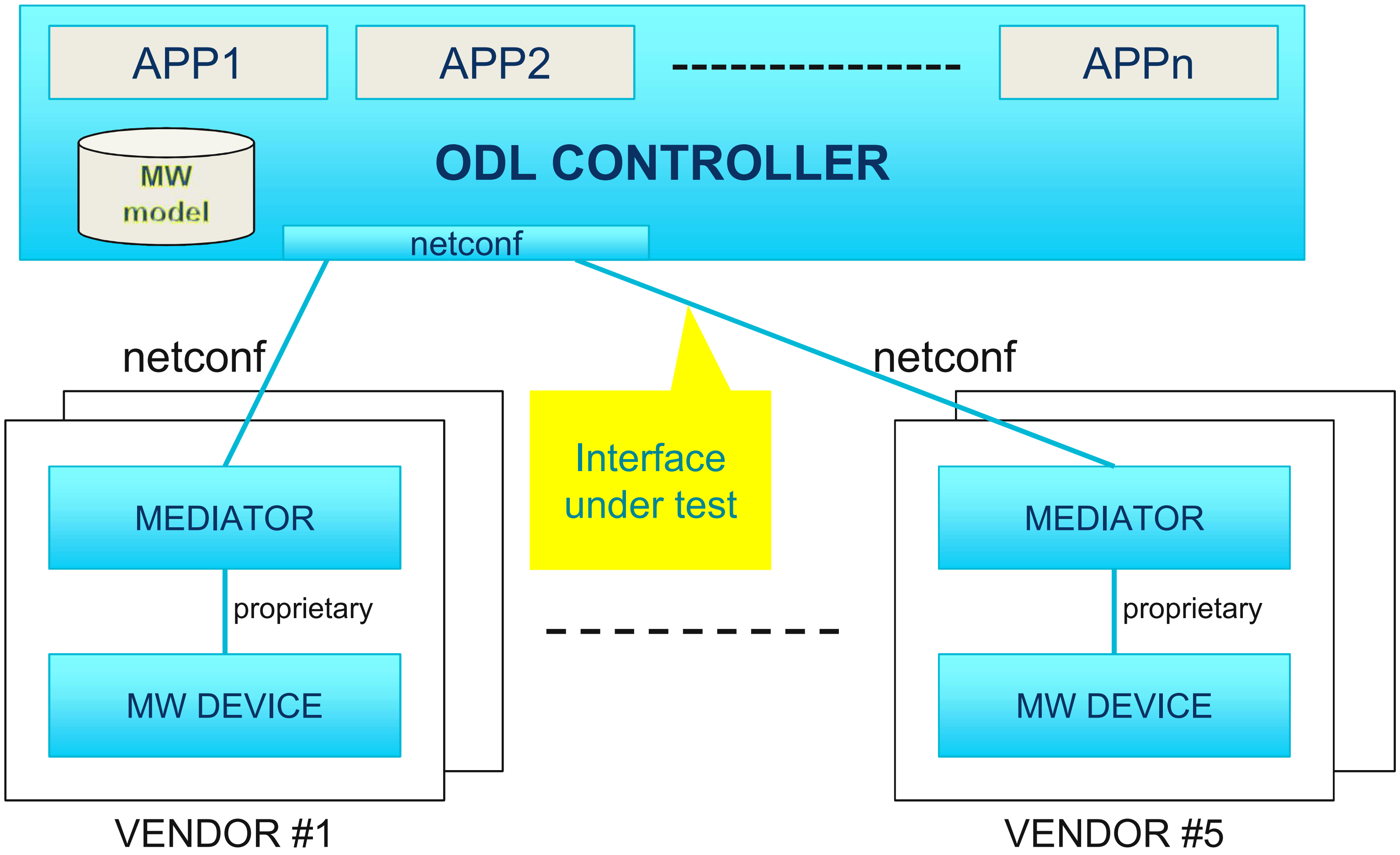
Second PoC Use Cases

- Detection and configuration of new microwave devices
    - Automated detection of NEs, making them available for configuration
- Detection of aberrances
    - Comparing the actual network configuration with external reference data, informing about aberrances and offer correction
- Detection and Visualization of the configured microwave network
    - Graphical overview about the momentarily configured network (= time variant in SDN managed network)
- Detection and Visualization of the currently effective network
    - Graphical overview about the momentarily actually effective network, highlighting deviations from the configured network
- Receiving and displaying of alarm information
    - Listing of events

Network Topology for the Second PoC



Network Architecture for the Second PoC



Second PoC Participants

- Operators, who provided content and organizational support:
  - Telefónica,
  - AT&T
- Microwave vendors:
  - Ceragon
  - Ericsson
  - Huawei
  - NEC
  - SIAE
- Integrators and Application Providers:
  - Highstreet Technologies,
  - Wipro,
  - Tech Mahindra
  - HCL
- Other Participants:
  - Viavi, ZTE, Deutsche Telekom

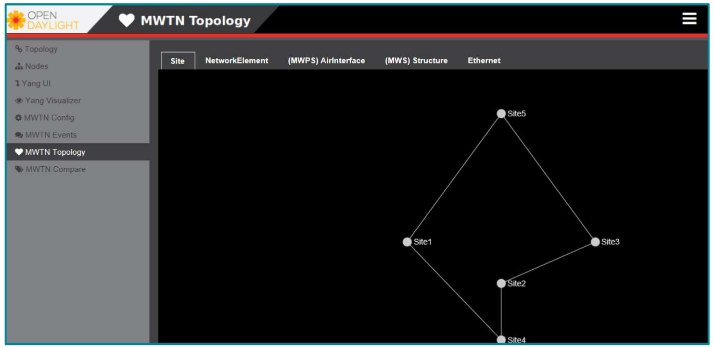
Second PoC outcomes

- Report describing the PoC developments
  - https://www.opennetworking.org/images/stories/downloads/sdn-resources/technical-reports/Wireless_Transport_SDN_PoC_White_Paper.pdf
- Demonstration environment available
  - Opportunity to access the information model developments at this stage
  - It can be exploited positively by operators and developers to assess the viability of the model
  - http://highstreet-tech.ddns.net:8181/index.html
- Contribution of the already developed artifacts to OpenDaylight


OPEN NETWORKING FOUNDATION

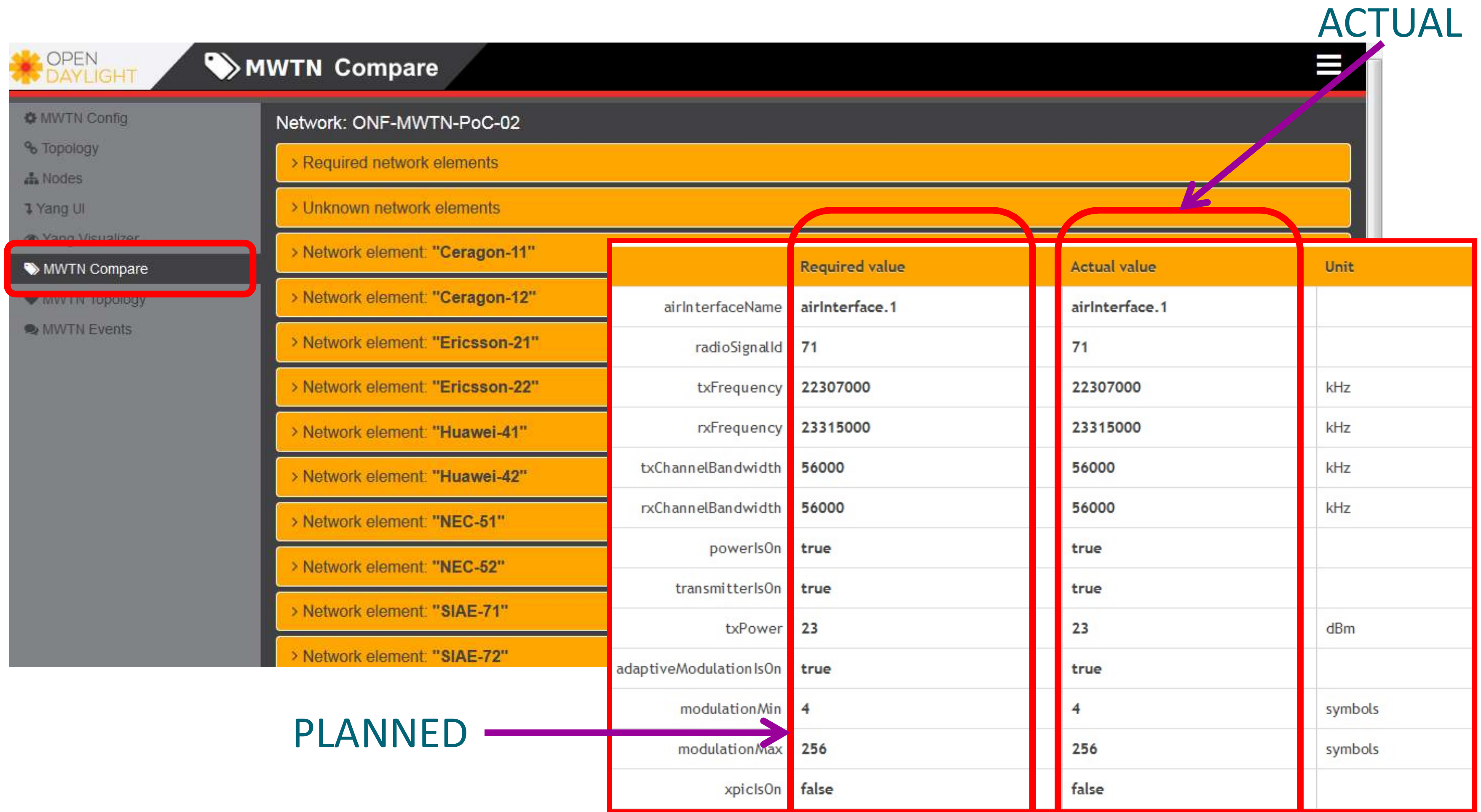
Wireless Transport SDN
Proof of Concept 2
Detailed Report

Version 1.0
June 6, 2016



Second PoC Applications

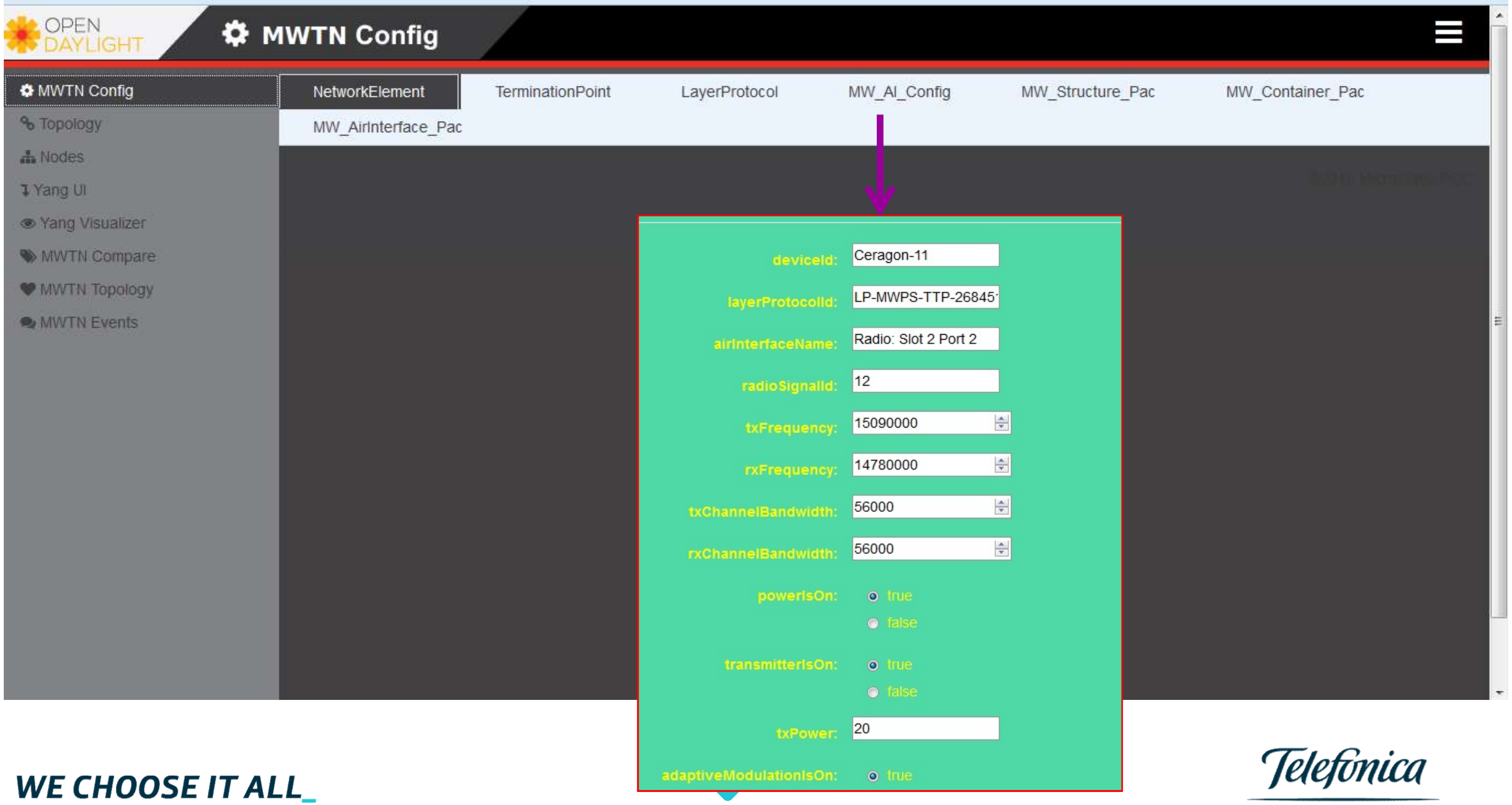
- APPLICATION #1: Usage of Opendaylight interface to Get node and interface parameters and check respect to planning:



	Required value	Actual value	Unit
airInterfaceName	airInterface.1	airInterface.1	
radioSignalId	71	71	
txFrequency	22307000	22307000	kHz
rxFrequency	23315000	23315000	kHz
txChannelBandwidth	56000	56000	kHz
rxChannelBandwidth	56000	56000	kHz
powerIsOn	true	true	
transmitterIsOn	true	true	
txPower	23	23	dBm
adaptiveModulationIsOn	true	true	
modulationMin	4	4	symbols
modulationMax	256	256	symbols
xpicIsOn	false	false	

Second PoC Applications

- APPLICATION #2: Usage of Opendaylight interface to Configure interface and node parameters



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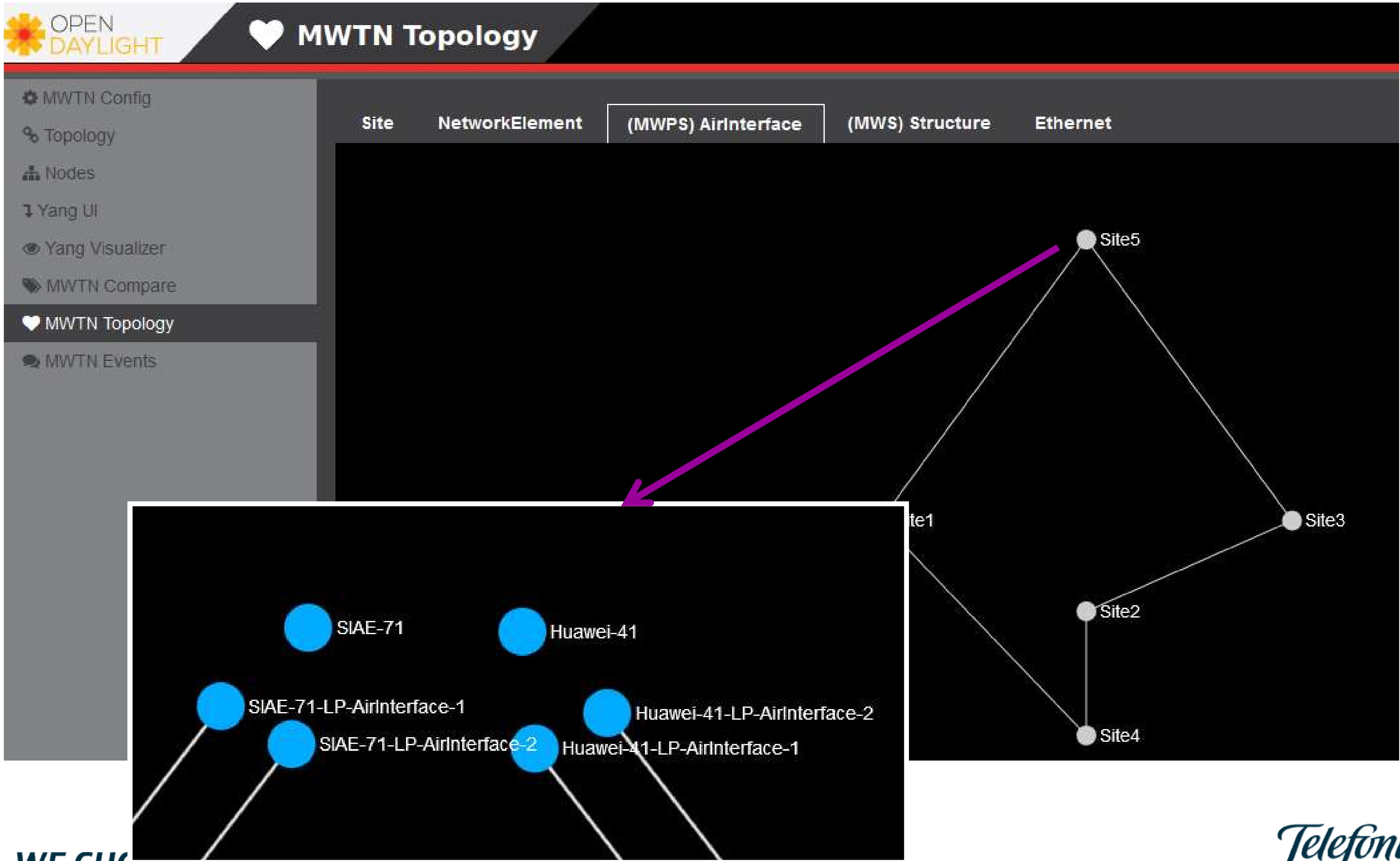
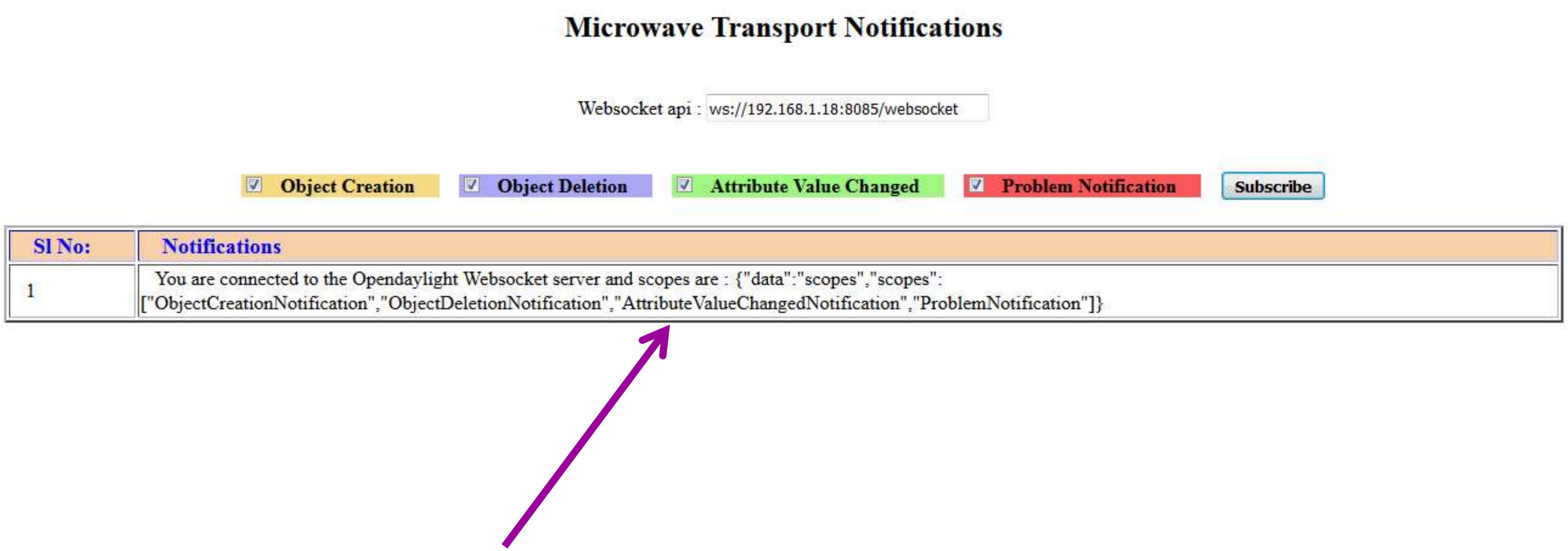
Second PoC Applications

- APPLICATION #3: Usage of Opendaylight interface to see deployed topology:



Second PoC Applications

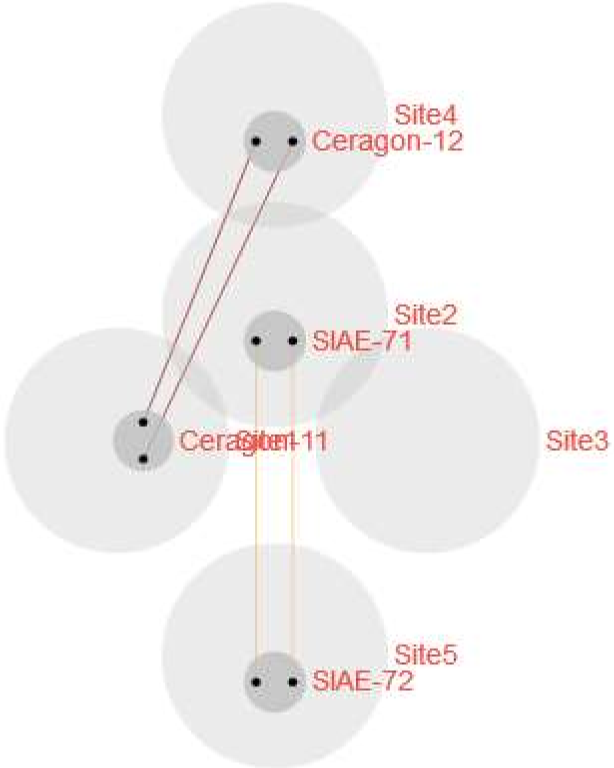
- APPLICATION #4: APP developed to get notificatios/alarms from the network elements:



A new line will raise in case

Second PoC Applications

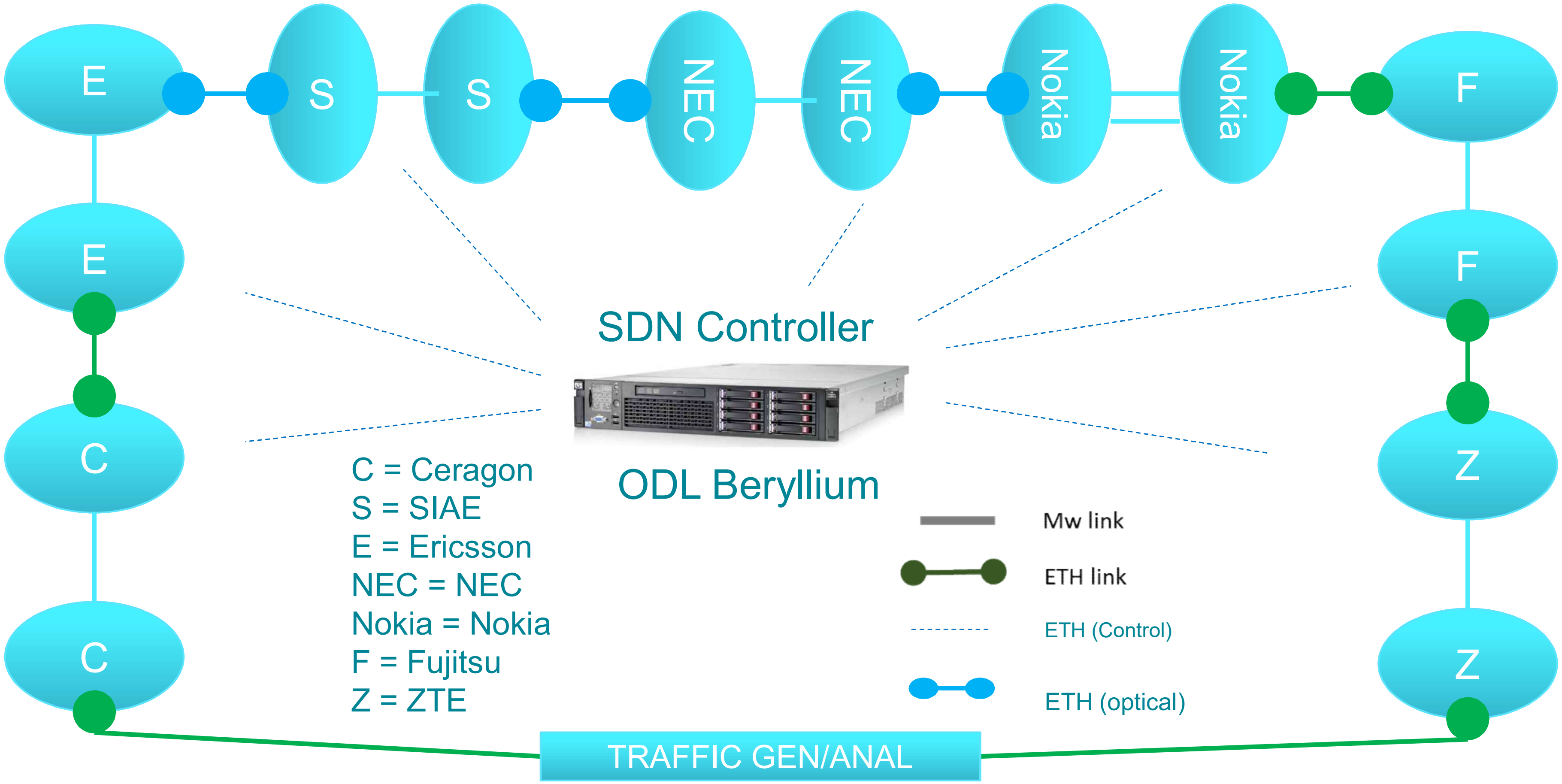
- APPLICATION #5: APP developed to represent graphically the topology and the connectivity among nodes:



Third PoC

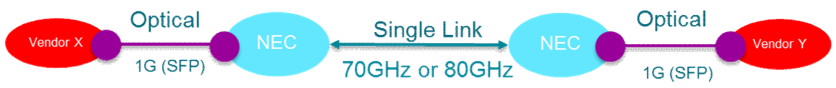
- Third Proof Of Concept (PoC) starting October 24th
- Organized by AT&T and hosted in the “Winlab” (Rutgers University) in New Jersey.
- Scope of the PoC:
  - Extend the standardized μWave/mmWave model in a multivendor microwave network from the so-called “Priority 1” attributes to be inclusive of Priority 2 and Priority 3 attributes as well
  - Re-execute the use cases herein carried forward from the 2nd PoC with the Priority 1/2/3 model
  - Verify/validate the extensibility of the Priority 1/2/3 model to mmWave equipment (both indoor and outdoor)
- Participants: AT&T, Telefonica, DT, Ceragon, Ericsson, Fujitsu, NEC, Nokia, SIAE, ZTE, Highstreet Technologies, Brocade, FRINX, Wipro,

Thrid PoC Set-up

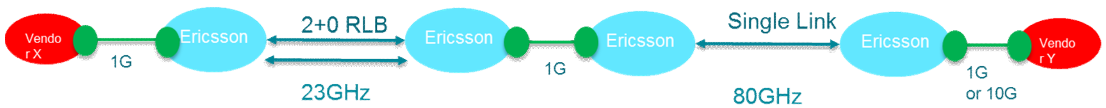


Set-Up Details

- NEC LINK:



- ERICSSON LINK:



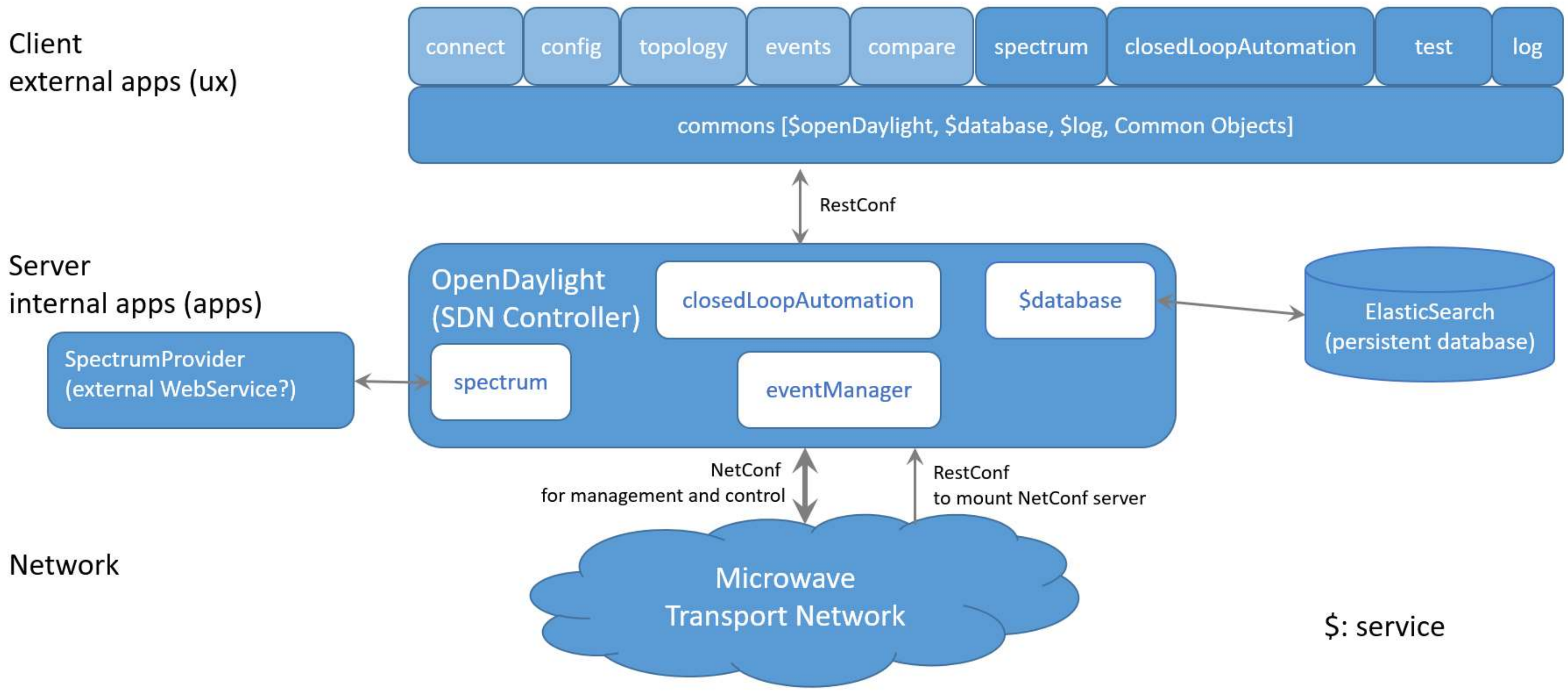
- CERAGON LINK:

- NOKIA LINK:

- SIAE LINK:

- ZTE LINK:

Software Architecture



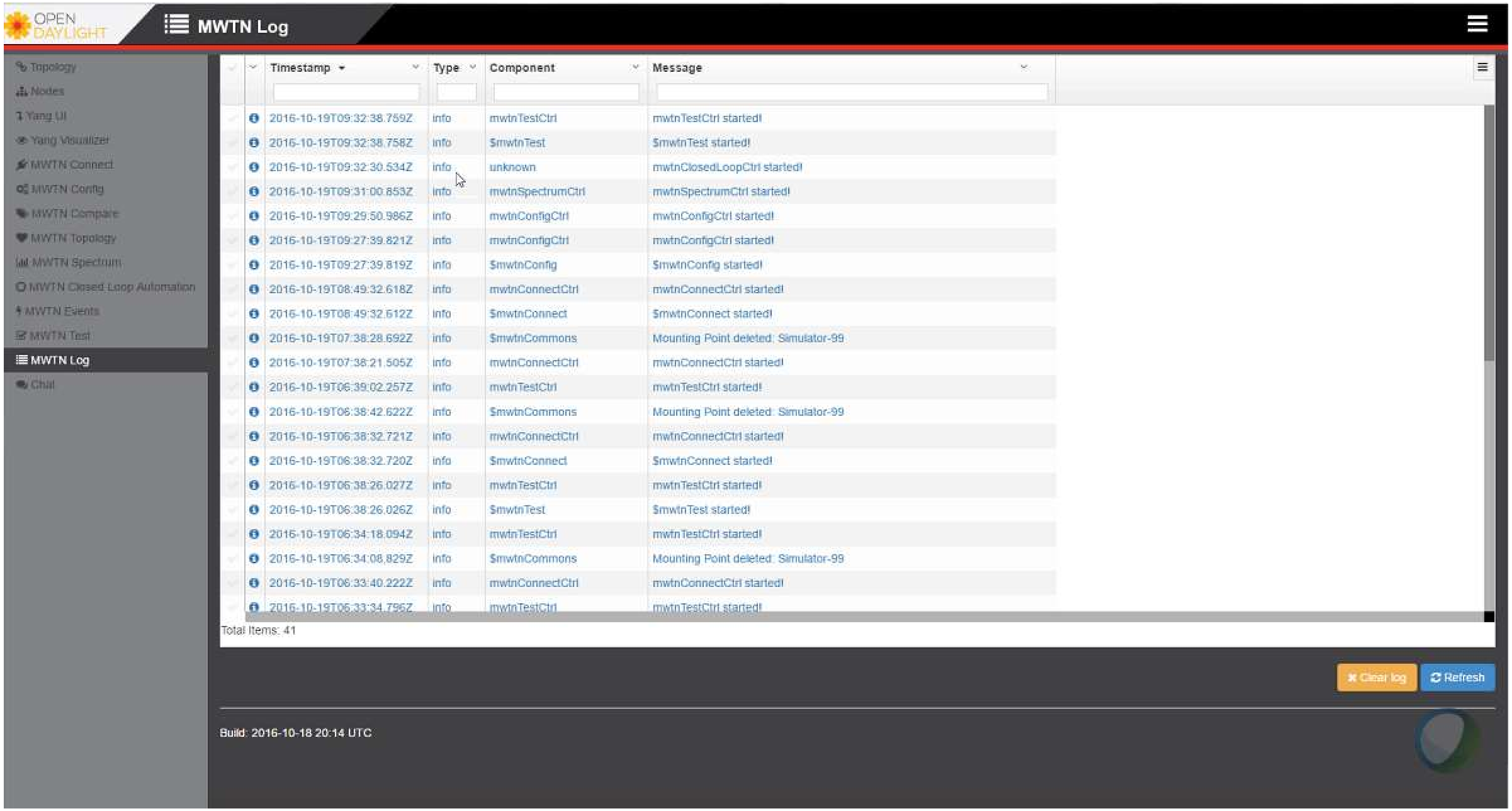
https://github.com/OpenNetworkingFoundation/CENTENNIAL/tree/master/03-WTP-PoC/code

Third PoC Use Cases

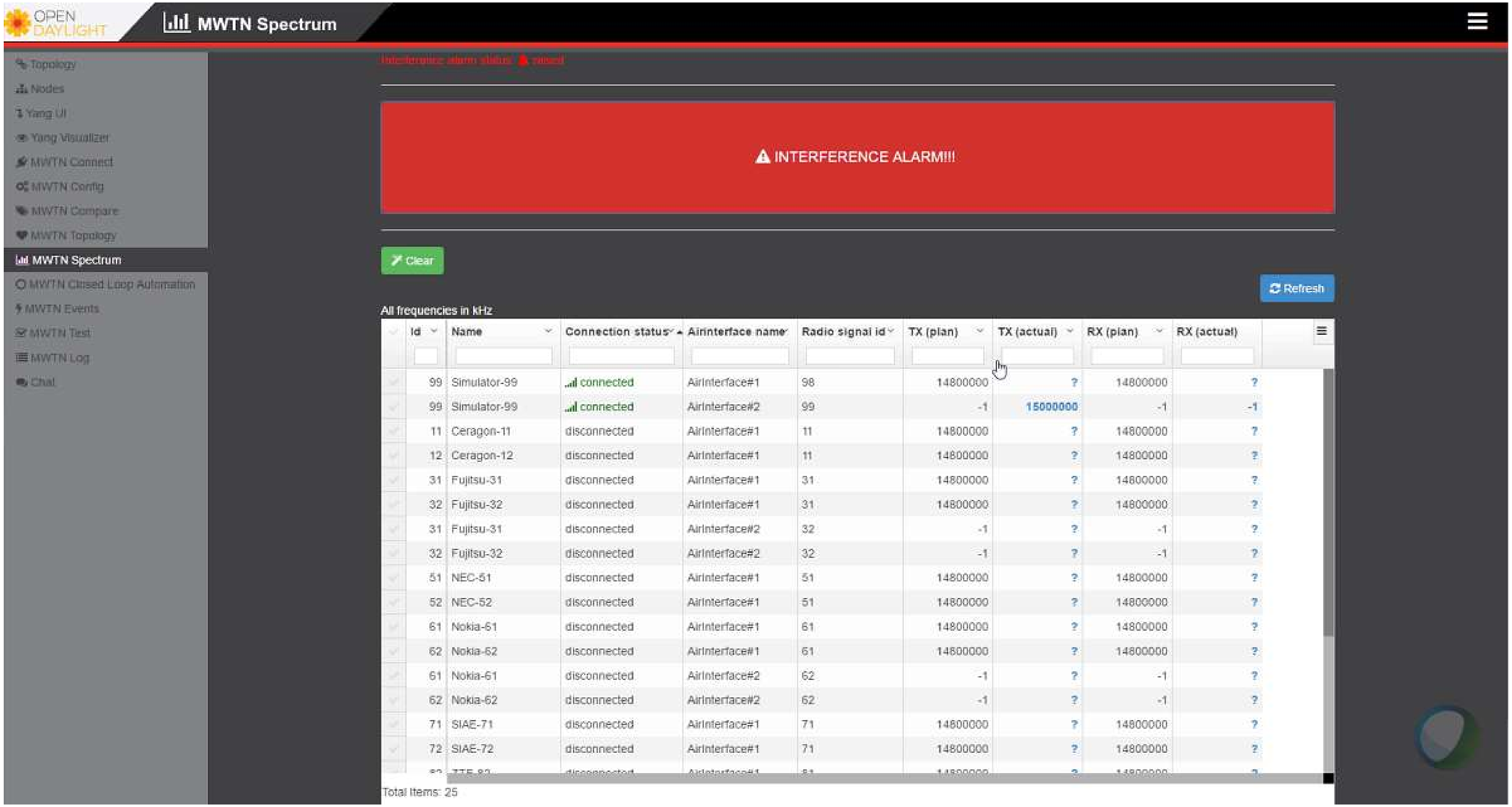
- Same use cases presented to second PoC
  - Detection and configuration of new microwave devices
  - Semi-automated configuring of microwave devices according to reference data
  - Detection and Visualization of the configured microwave network
  - Detection and Visualization of the currently effective network
  - Receiving, displaying and storing of alarm information

- New use cases:
  - Test automation -> automatic NetConf test of the model
  - Spectrum management
  - Closed loop automation (including performance management)
  - Event Management (improvement of the second PoC)

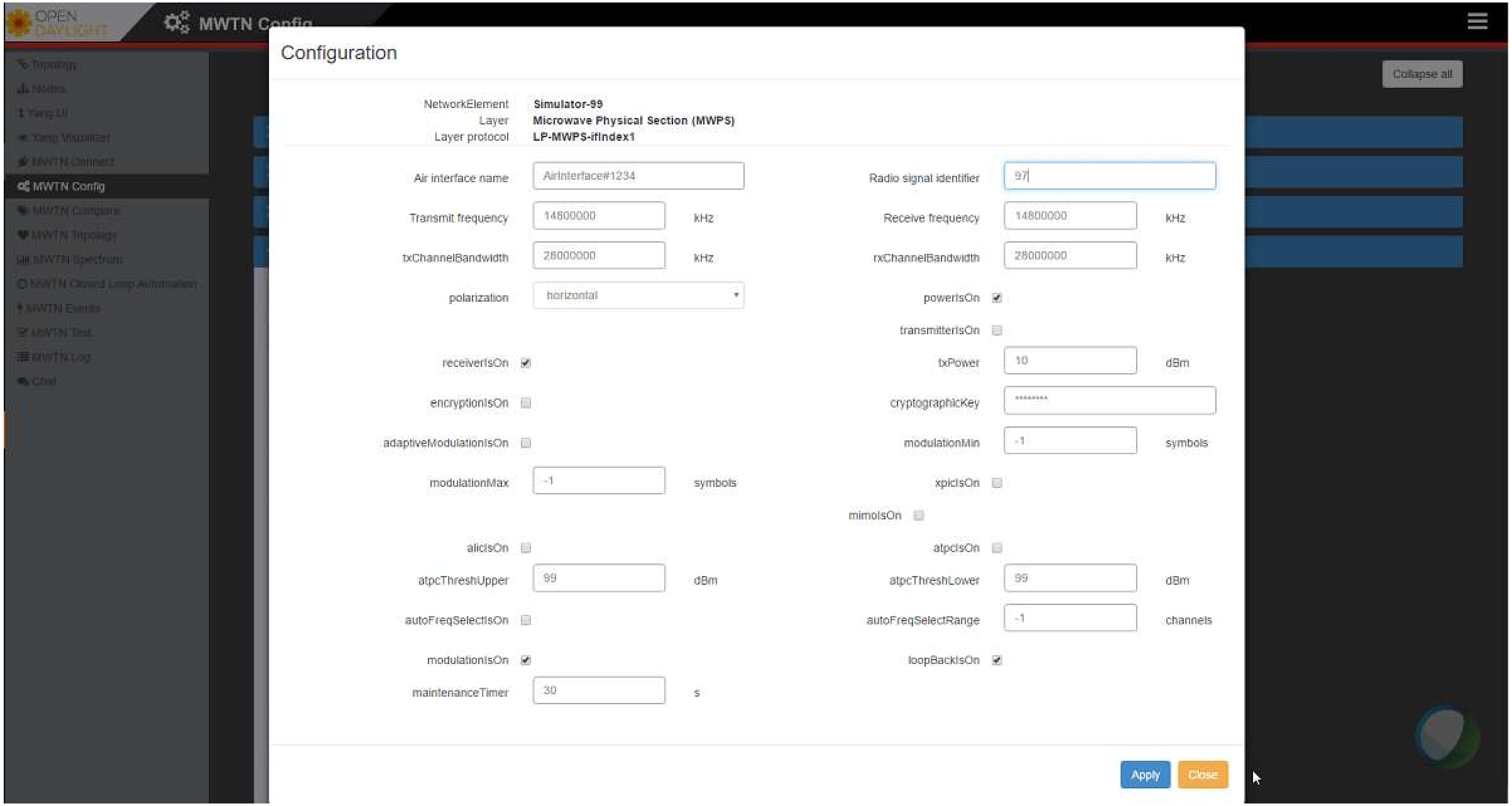
Log


OPEN DAYLIGHT
MWTN Log
Topology
Nodes
Yang UI
Yang Visualizer
MWTN Connect
MWTN Config
MWTN Compare
MWTN Topology
MWTN Spectrum
MWTN Closed Loop Automation
MWTN Events
MWTN Test
MWTN Log
Chat
Timestamp
Type
Component
Message
2016-10-19T09:32:38.759Z info mwtnTestCtrl mwtnTestCtrl started!
2016-10-19T09:32:38.758Z info $mwtnTest $mwtnTest started!
2016-10-19T09:32:30.534Z info unknown mwtnClosedLoopCtrl started!
2016-10-19T09:31:00.853Z info mwtnSpectrumCtrl mwtnSpectrumCtrl started!
2016-10-19T09:29:50.986Z info mwtnConfigCtrl mwtnConfigCtrl started!
2016-10-19T09:27:39.821Z info mwtnConfigCtrl mwtnConfigCtrl started!
2016-10-19T09:27:39.819Z info $mwtnConfig $mwtnConfig started!
2016-10-19T08:49:32.618Z info mwtnConnectCtrl mwtnConnectCtrl started!
2016-10-19T08:49:32.612Z info $mwtnConnect $mwtnConnect started!
2016-10-19T07:38:28.692Z info $mwtnCommons Mounting Point deleted: Simulator-99
2016-10-19T07:38:21.505Z info mwtnConnectCtrl mwtnConnectCtrl started!
2016-10-19T06:39:02.257Z info mwtnTestCtrl mwtnTestCtrl started!
2016-10-19T06:38:42.622Z info $mwtnCommons Mounting Point deleted: Simulator-99
2016-10-19T06:38:32.721Z info mwtnConnectCtrl mwtnConnectCtrl started!
2016-10-19T06:38:32.720Z info $mwtnConnect $mwtnConnect started!
2016-10-19T06:38:26.027Z info mwtnTestCtrl mwtnTestCtrl started!
2016-10-19T06:38:26.026Z info $mwtnTest $mwtnTest started!
2016-10-19T06:34:18.094Z info mwtnTestCtrl mwtnTestCtrl started!
2016-10-19T06:34:08.829Z info $mwtnCommons Mounting Point deleted: Simulator-99
2016-10-19T06:33:40.222Z info mwtnConnectCtrl mwtnConnectCtrl started!
2016-10-19T06:33:34.796Z info mwtnTestCtrl mwtnTestCtrl started!
Total Items: 41
Clear log
Refresh
Build: 2016-10-18 20:14 UTC

Spectrum Management



Configuration



03 ONF Information Model

Information Model

https://github.com/OpenNetworkingFoundation/CENTENNIAL/tree/master/03-WTP-PoC/models

Information model is the key for the work being done:

- It is operator-driven
- It incorporates inputs from all key MW vendors
- It provides the ability to read/configure attributes and alarms/PMs handling
- It includes around 350 MW attributes
- A subset of 64 priority 1 attributes was covered by 2nd MW PoC
- The complete model is intended to be tested in 3rd PoC

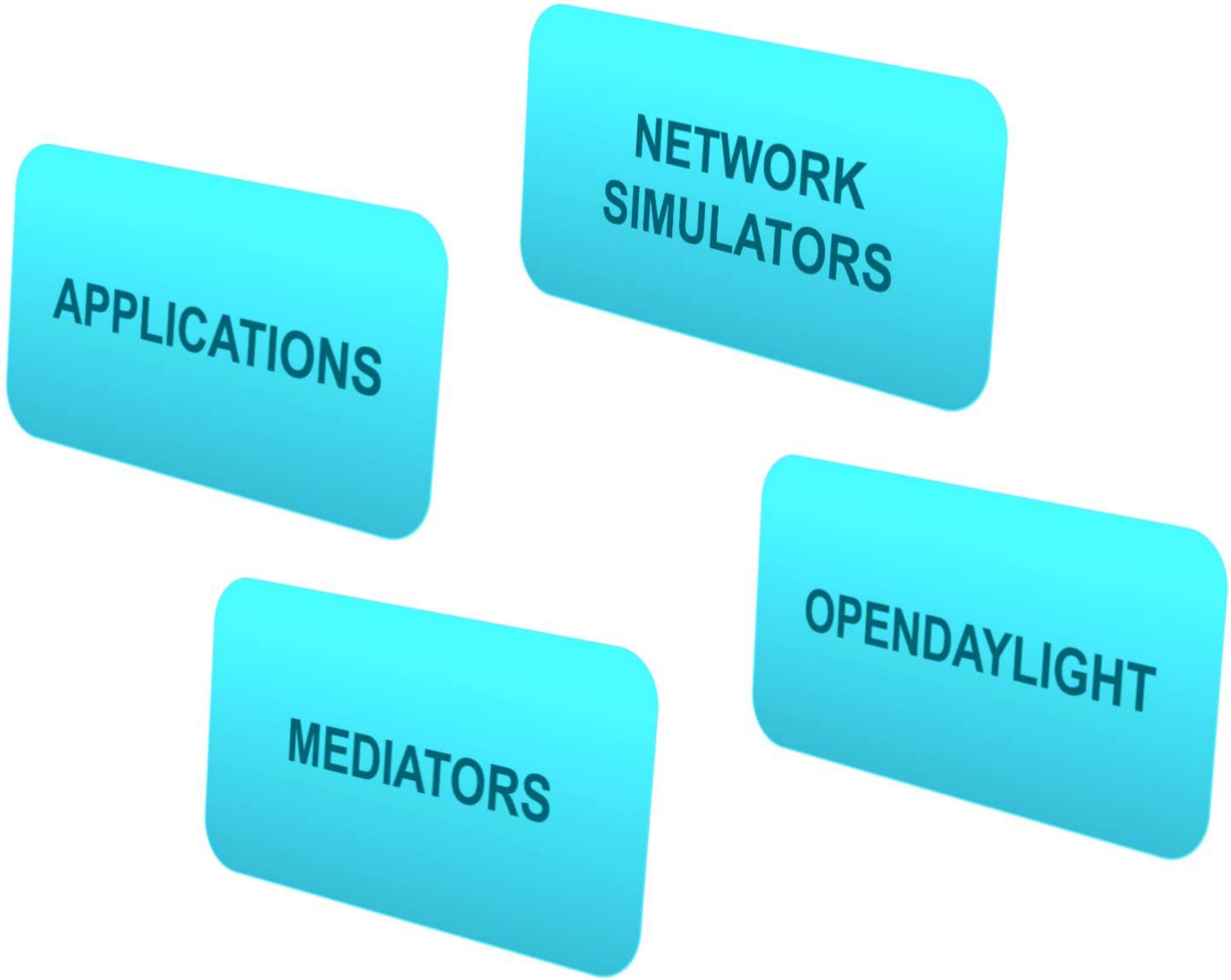
INFORMATION MODEL

OPEN NETWORKING FOUNDATION

ONF vs IETF

- ONF is working on SDN for MW since 2013
  - PoCs done, SW developed, Info Model defined
  - Mature work, real MW community, all Telefonica vendors represented
- Very recently (March 2016) some vendors have presented an alternative model in IETF
  - No real MW community in IETF
  - Set-up of a Design Team for start drafting the model
  - Telefonica participating to avoid standards fragmentation (problem statement and gap analysis)
- Next actions:
  - Foster the public release of the ONF model
  - Ensure alignment in IETF and ONF (avoiding overlaps and contradictions)

Building Blocks



Building blocks

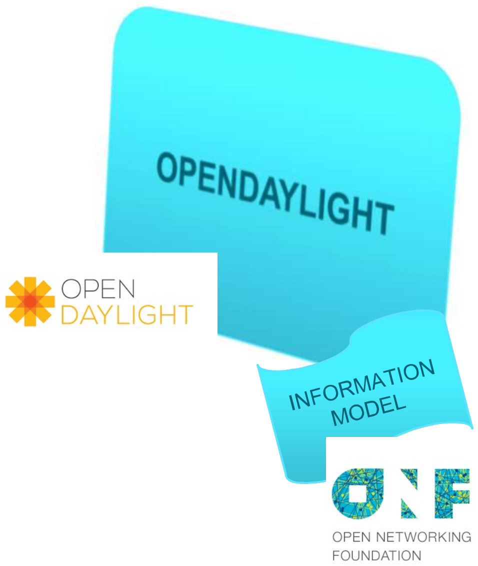
A key concept introduced in the 2nd PoC were the mediators which translate the Netconf/YANG MW information model to vendor specific configuration and vice-versa

- This enabled working group to save time in development and debugging phase
- This enabled to share code between vendors (all mediators share the same NBI)

Migration Path and Legacy Networks

- Using the mediator concept operators will be able to deploy SDN apps in existing networks by running multiple mediators in the cloud to interact with existing MW NEs
- This facilitates to integrate legacy network elements in a smooth way, making the network ***SDN-ready*** from day 0
  - ***investment protection, key for operators***
- Simple monitoring applications would smoothen transmission from trials to live network operation

Building blocks



The information model is incorporated into ODL via YANG model plugins

- In order to support event we extended the ODL source code (to be upstreamed to the ODL)
- A testing framework has also been developed which can be used for ODL continues integration
- Anyone is now able to download ODL, install the MW plugins and run MW apps

Building blocks

The Applications are addressed via Restconf APIs

- API directly derived from the YANG models read from the devices
- Applications from 4 different contributors managed hardware from 5 different vendors
- Applications will be made available on a demo platform (with Default Value Mediators beneath)

Building blocks

The mediators developed contain a pure SW implementation enabling the simulation of a MW network without the actual physical equipment

- Telefonica plans on maintaining a server running the ODL and MW apps leveraging the simulated mediator for future development

04

Demo

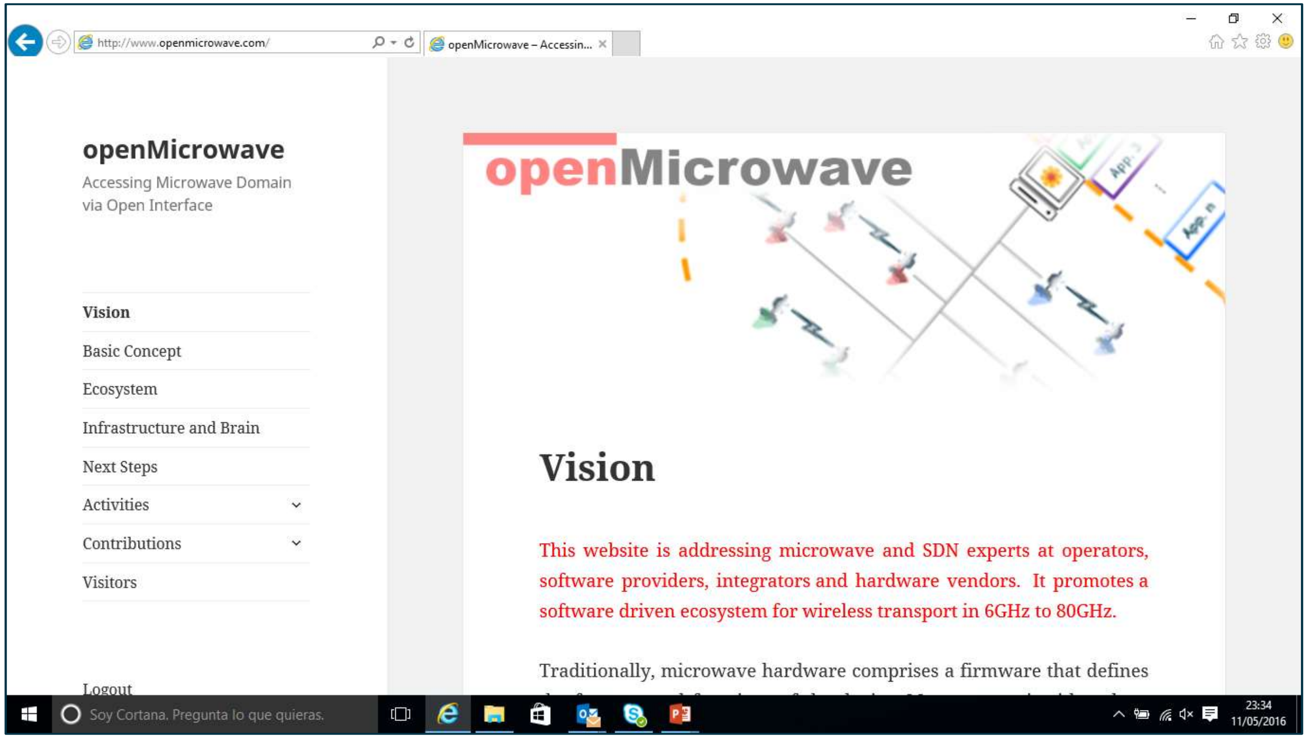
05 Conclusions and Next Steps

Future Steps

- Execution of the 3rd PoC for validation of the full WT information model (~300 attributes)
- Experimenting with the test environment available
- Formalizing the WT information model as an ONF TR document
- Hardening the SDN applications presented
- Contributing code artefacts to ODL
- Preparing for the next PoC in Q2 2017
- Engage other operators to join this effort, ensuring that the Information Model addresses operator’s needs
  - Recent release of Telefónica RFQ for MW equipment already asking for support of the ONF model

Public website to track progress
http://www.openmicrowave.com/

- Public repository collecting all the progress about SDN for MW (Information Model, use cases, applications, etc)
- Work for the 3rd PoC will be posted here



We encouraging interested parties to register and participate

Recognitions to Telefónica activity on SDN for Transport (in 2016)

- ONF Recognition to Thorsten Heinze (O2 Germany) for the outstanding contribution to the work related to the applicability of SDN to Wireless Transport Network

- Telefónica named winner of the LTE & 5G World Awards 2016 (https://5gworldevent.com/) in the category of "Best NFV/SDN Solution" for the work done around SDN applied to transport technologies with end to end scope (from access to core, including wireless and wired technologies).

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5G Crosshaul http://5g-crosshaul.eu/

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Thanks!!
… and stay tunned for the results of the 3rd PoC