◊ Open Transport Configuration & Control ………. ……………… Lyndon Ong (Ciena)

◊ Config & control wireless networks with CIM & SDN-C ………. Tracy Van Brakle (AT&T)

◊ First Joint ONF/ONAP Demonstration with SDN-R.…………… George Clapp (AT&T)

12 December 2017

Open Transport Configuration & Control

Lyndon Ong (Ciena)

New ONF – 200+ Members Strong
Community Positioned for Success

Partner

Operators

Vendors

ONF Board

ONF (& Stanford) Guru Parulkar

<u>Network Operators</u>

AT&T	DT
Turk Telecom	Comcast
NTT Comm	Google
SK Telecom	Telefonica
Verizon	

<u>Research & Vendor Community</u>

Nick McKeown	Stanford
Fabian Schneider	NEC

Innovator

SK Telecom	Microsoft
China Mobile	DoD
Chunghwa Tel	TELUS
CENX	Tencent
China Telecom	Vodafone
Juniper	ZTE
Infinera	Ceragon
Others	

Collaborator

70+

Volunteers

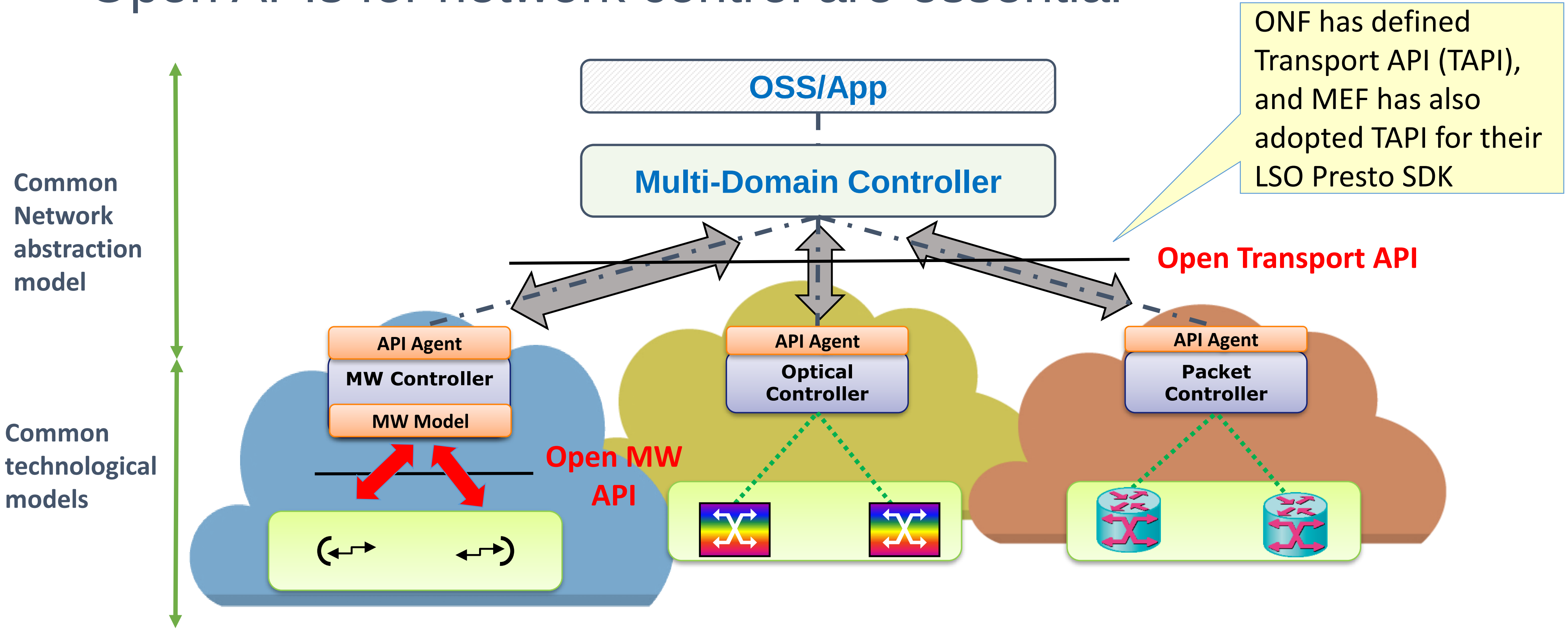
100s

ONF Open Transport Config & Control (OTCC) Project

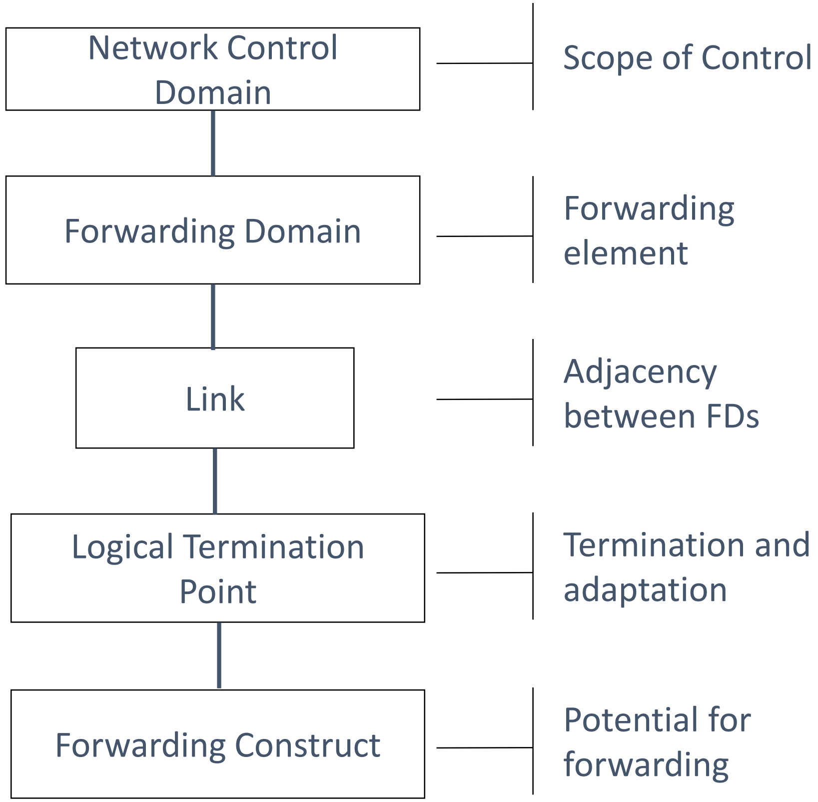
- Mission
  - Promote common configuration and control interfaces for transport networks in SDN, defining these interfaces with open source software and software defined standards
- Leadership – OTCC TST
  - Lyndon Ong, Ciena, OTCC project lead
  - Giorgio Cazzaniga, SIAE, Wireless Transport sub-project lead
  - Karthik Sethuraman, NEC, Transport API sub-project lead
  - Kam Lam, Fiberhome, OT Info Model sub-project lead
- Results
  - OpenFlow extensions for optical
  - Transport API Functional Requirements and SDK (related OIF and MEF demonstrations)
    - https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport
  - Wireless Transport Information Model (related WT PoCs)

API Definition and Development

- Open APIs for network control are essential



Common Information Model (simplified)



- Model of data plane resources in an SDN-enabled network
  - Technology agnostic
  - Recursive (Forwarding Domain may contain FDs)
  - Models static and dynamic elements
  - Extensible to different technologies and environments

Product of the ONF Information Modeling and Tooling Project
ONF TR-512 Core Information Model v1.3 – see
https://wiki.opennetworking.org/display/OIMT/Ready+for+ONF+Approval

Configuring and controlling wireless networks with ONF CIM & ONAP SDN-C

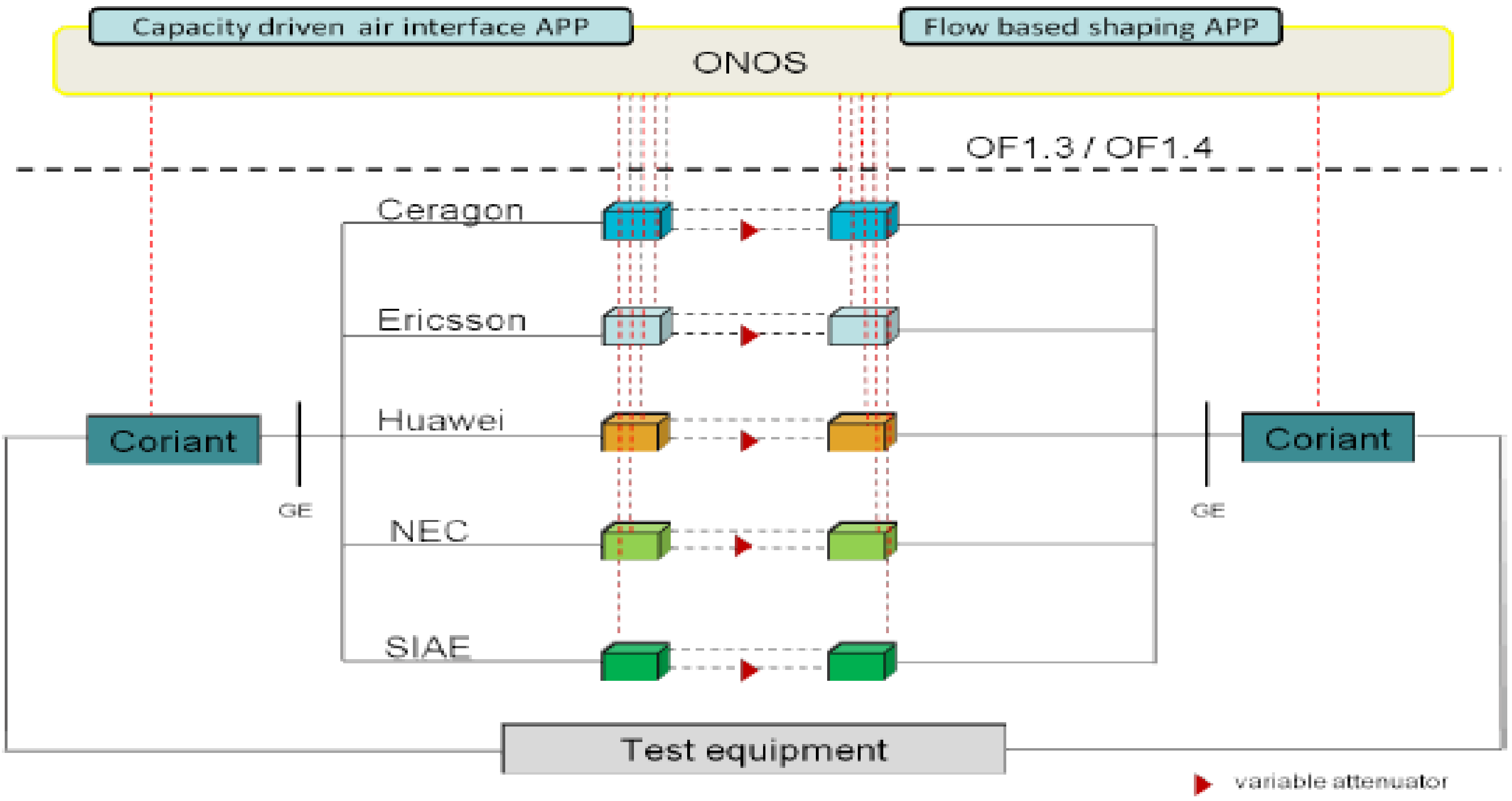
Tracy Van Brakle (AT&T)

Overview and background

Proofs of Concept (PoCs) have been executed by the Open Networking Foundation Wireless Working Group(s) roughly every six months to demonstrate progress and to verify functionality and enhancements in a multi-vendor wireless network using real network devices, beginning with µWave/mmWave and now inclusive of eNB, RRH, DAS, IoT sensors.
The work began with ONOS, then ODL stand-alone, and now ONAP SDN-C

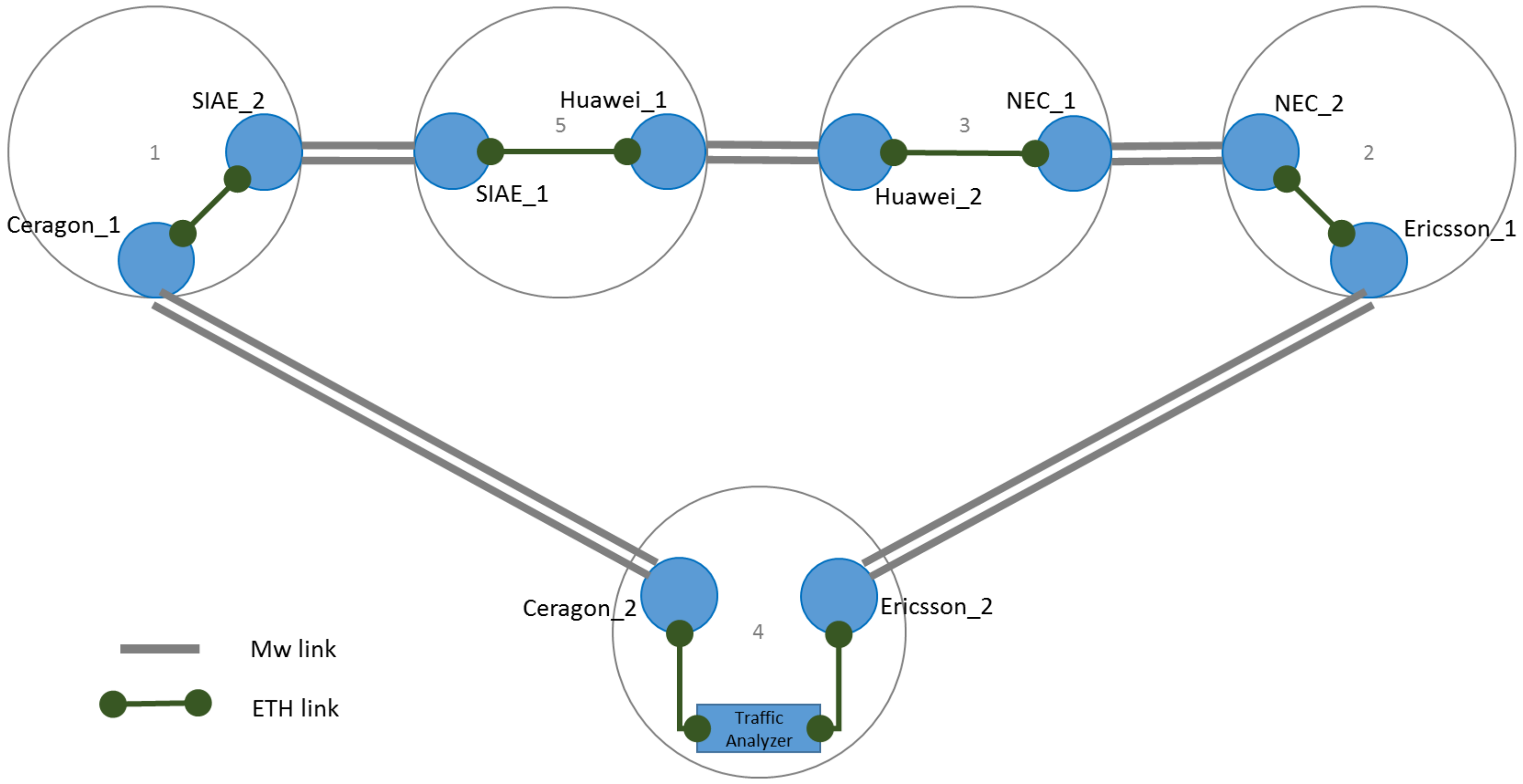
Date + Sponsor	SDN controller and platform	ONF CoreModel (TRs 512 & 532)	SBI protocol
1st PoC; 4Q'15; Telefonica	ONOS	n/a	OpenFlow
2nd PoC; 2Q'16; Telefonica	ODL Lithium SR4	n/a	Netconf/YANG
3rd PoC; 4Q'17; AT&T	ODL Beryllium SR2 (ECOMP)	CM 1.1	Netconf/YANG
4th PoC; 2Q'17; Deutsche Telekom	ODL Boron SR1 (ONAP release 0)	CM 1.2	Netconf/YANG
5th PoC; 4Q'17; AT&T	ODL Boron / Carbon (ONAP "pre" Amsterdam)	CM 1.2	Netconf/YANG
6th PoC; 2Q'18 - TBD	ODL Nitrogen (ONAP Beijing)	CM 1.3	Netconf/YANG

1st Proof-of-Concept → two basic SDN applications, OpenFlow – October 2015



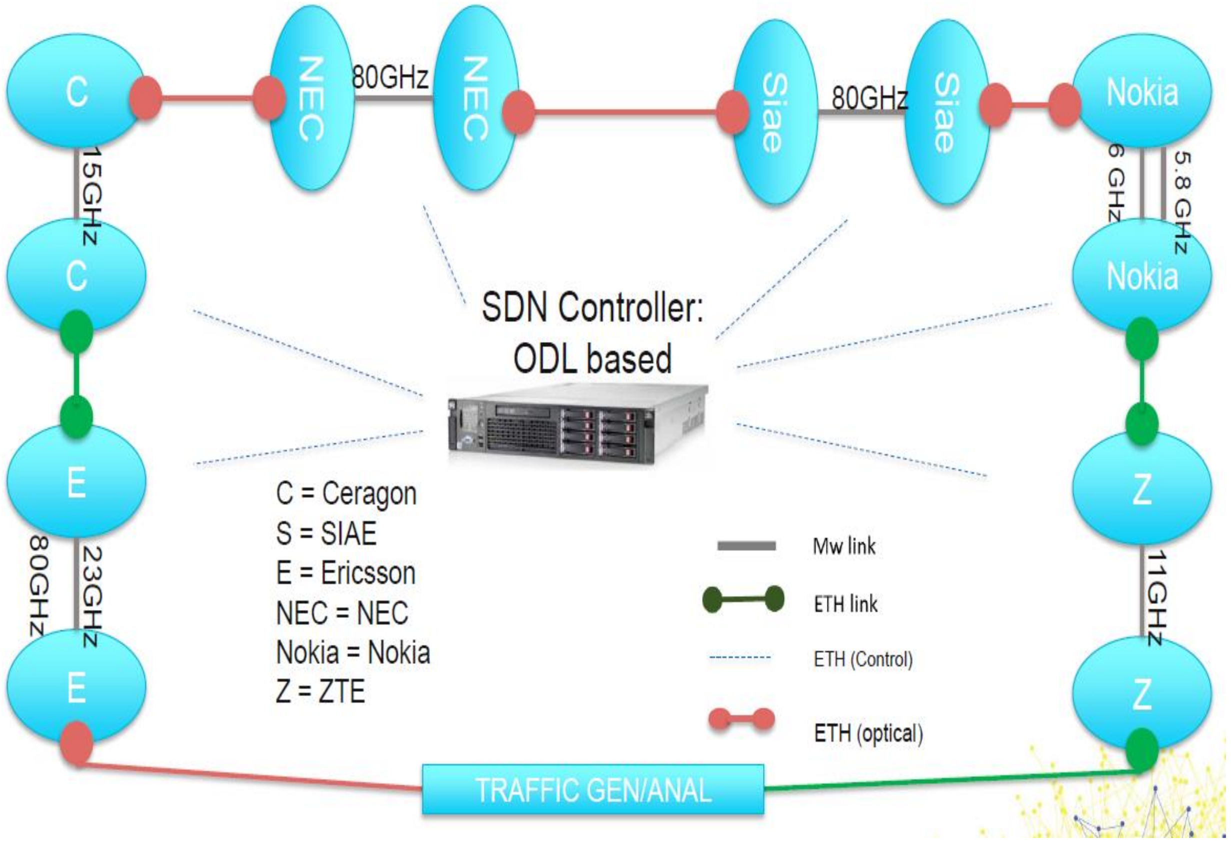
- **1st PoC took place in Madrid, Spain, October 2015**
- **Sponsor/Host = Telefónica and IMDEA Networks, AT&T (observer)**
- **Equipment vendors (in alphabetical order): Ceragon, Coriant, Ericsson, Huawei, NEC and SIAE**

2nd Proof-of-Concept → FCAPS, ODL – April 2016



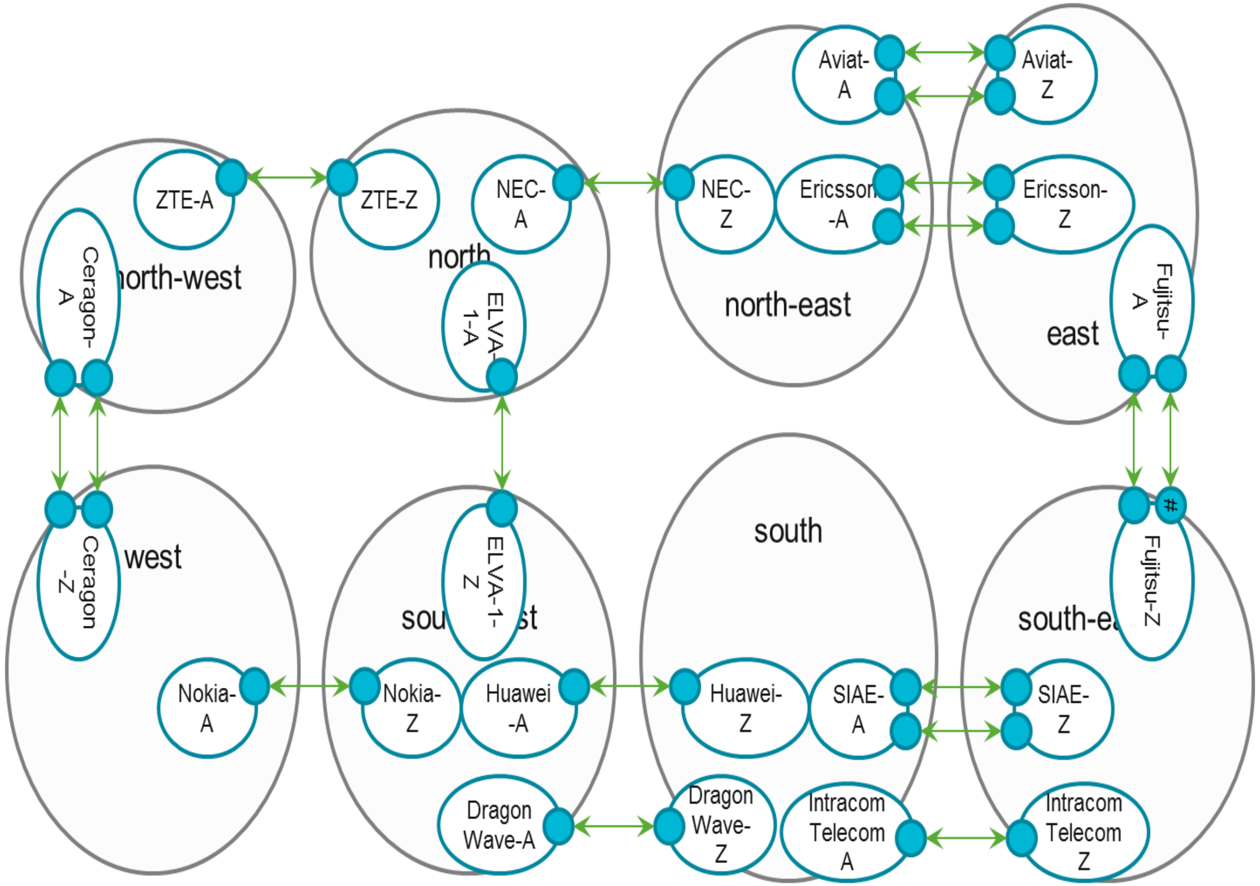
- **2nd PoC took place in Munich, Germany, April 2016**
- **Service Providers / Operators: Telefónica (lead), AT&T, Deutsche Telekom (observer)**
- **Equipment vendors (in alphabetical order): Ceragon, Ericsson, Huawei, NEC and SIAE**

3rd Proof-of-Concept → ECOMP (closed loop), Spectrum Access System inter-op



- **3rd PoC took place in Rutgers University Winlab, October 2016**
- **Service Providers / Operators: Telefónica, AT&T (lead), Deutsche Telekom**
- **Equipment vendors (in alphabetical order): Ceragon, Ericsson, Huawei, NEC, Nokia, SIAE, ZTE**

4th Proof-of-Concept → 1588v2, connection-oriented Ethernet with re-routing

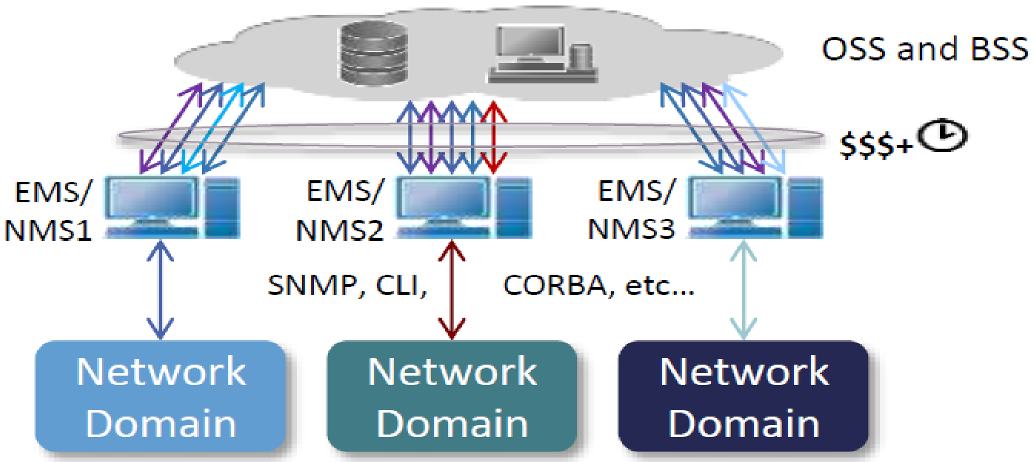


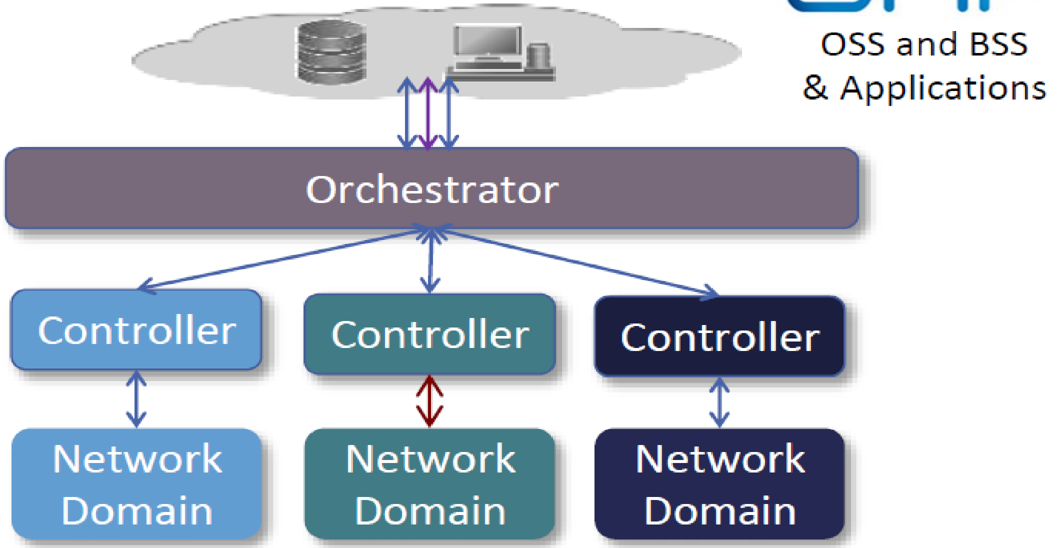
		Netconf/YANG (ONF-TR-512, 532)	Ethernet model	PTP (1588) model
Vendors	ADVA		X	X
	Aviat	X		
	Ceragon	X	X	
	DragonWave	X		
	ELVA-1	X		
	Ericsson	X	X	X
	Fujitsu	X		
	Huawei	X		X
	Intracom Telecom	X		
	NEC	X	X	X
	Nokia	X	X	X
	SIAE	X	X	X
	ZTE	X	X	X

- 4th PoC took place in Bonn and Prague, June 2017
- Service Providers / Operators: Deutsche Telekom (lead), Telefónica, AT&T, Orange (observer)

Overarching objectives for PoCs 2/3/4

Use Case: Multi-Vendor network integration





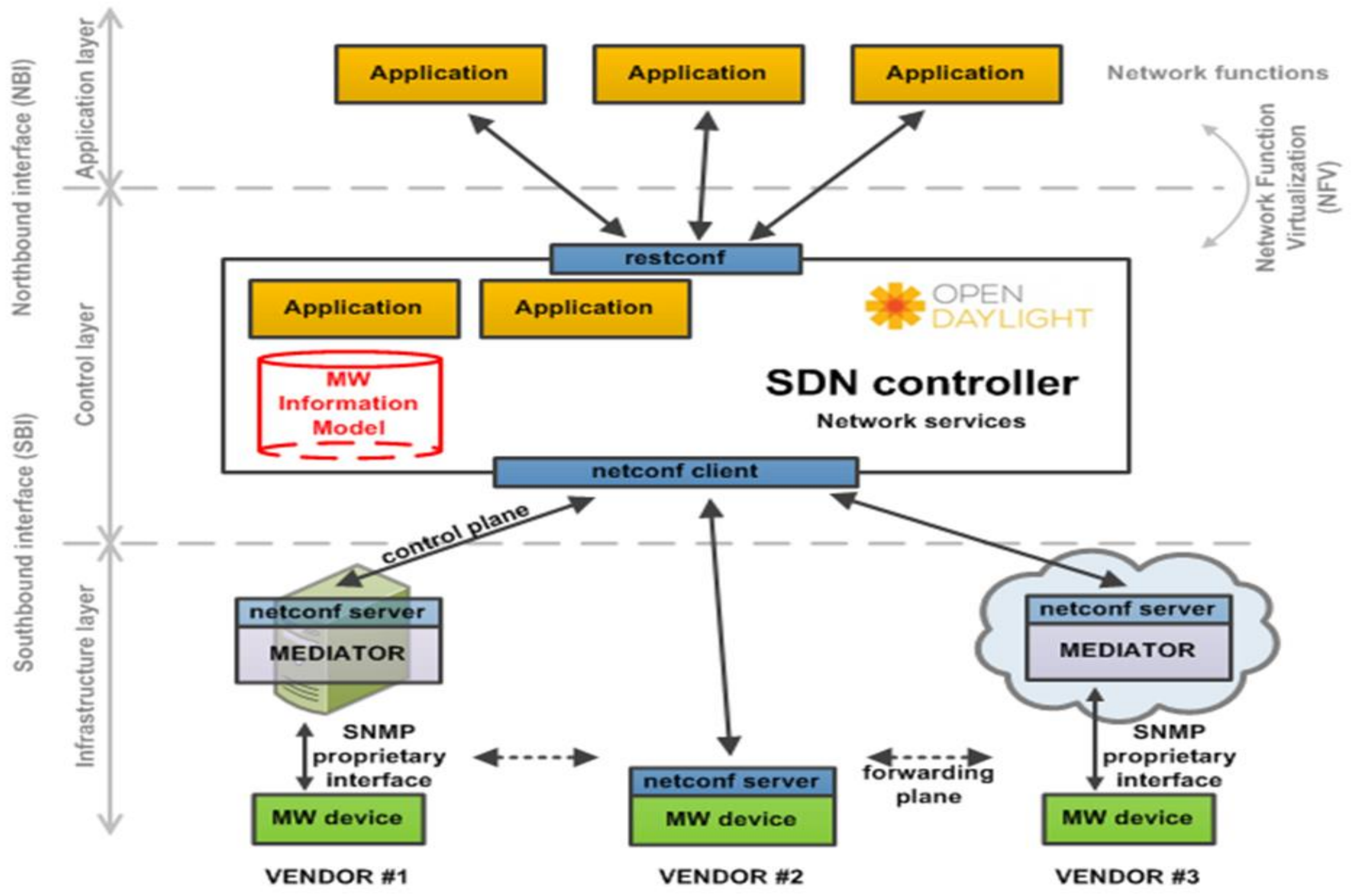
Current Situation:

- Individual EMS/NMS per vendor
- Huge complexity and cost in building/maintaining OSS/BSS – EMS/NMS interfaces
- Complex and slow for introducing new services spanning multiple network domains

SDN:

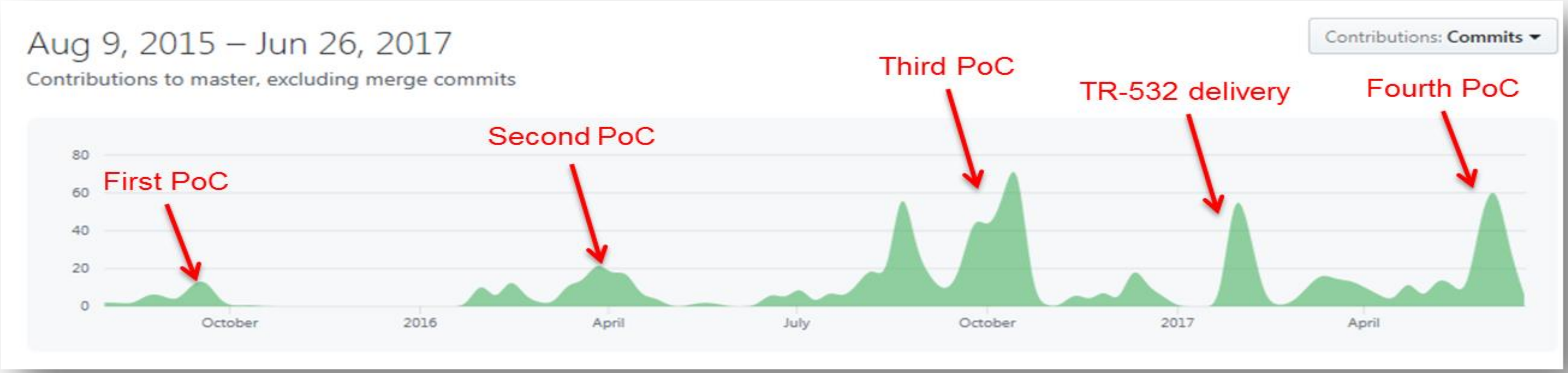
- New level of programmability on top of orchestrator
- EMS/NMS bypassed for service creation – standardised & simplified workflow
- Open Source based orchestrators for project speed up
- Reduced complexity through abstraction & virtualization in controller / orchestrator NBI

Basic architecture for ONF Wireless PoCs 2,3,4

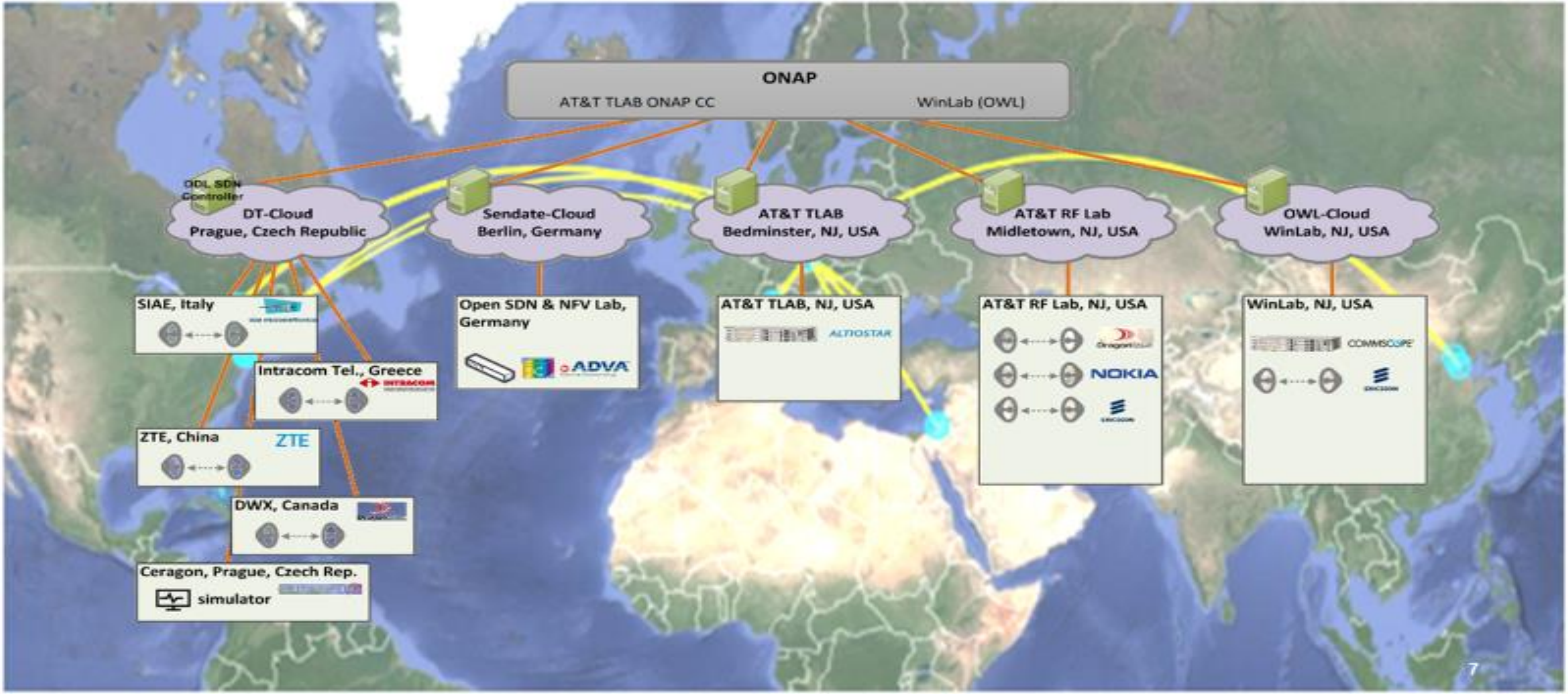


CENTENNIAL

- CENTENNIAL is the open source project being used for (and by) the ONF Wireless Project to deliver code that implements the microwave (and now more generalized model) defined by the ONF Wireless WGs.
- Applications developed in the context of the PoC are also available in CENTENNIAL project repository.



5th Proof-of-Concept →October 2017



Special thanks to the Community!

ALTIOSTAR

TEXAS

T · · ·

INTRACOM TELECOM

ERICSSON

COMMSCOPE®

CERAGON

Aviat NETWORKS

HUAWEI

at&t

RUTGERS

sm optics

DragonWave

WINLAB

ADVA™ Optical Networking

NEC

ZTE

ELVA-1 Millimeter Wave Division

IEEE 5G

SPIRENT

highstreet technologies Network solutions

FUJITSU

NOKIA

Telefónica

FRINX THE OPEN SOURCE NETWORK

TECHNISCHE UNIVERSITÄT CHEMNITZ

First Joint ONF/ONAP Demonstration with SDN-R

George Clapp

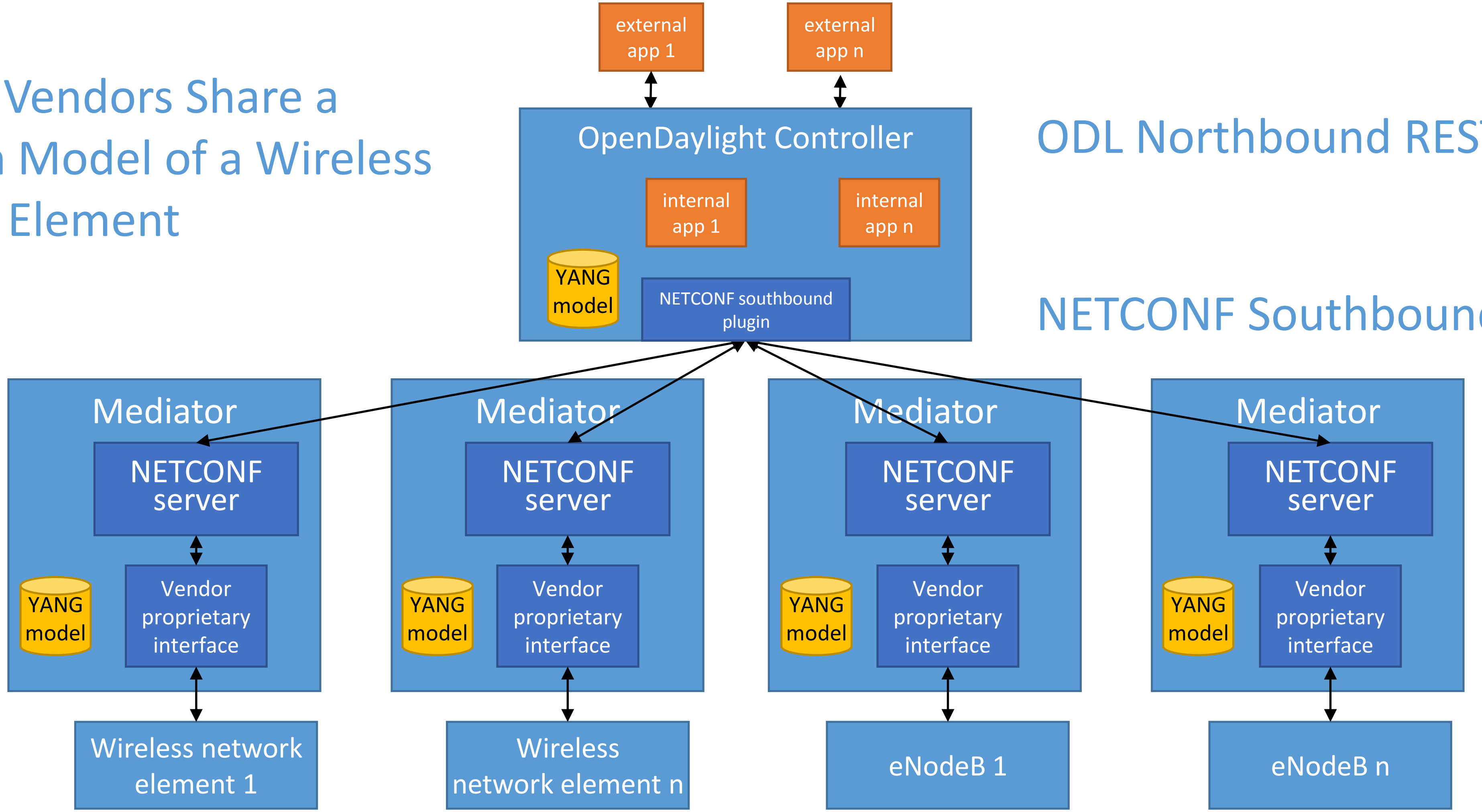
ONF Open Transport Working Group - Wireless Transport Project – Proof-of-Concept Demo

ONF / ONAP joint PoC participants and locations

Vendor	Type of test devices	Location of test devices	Connected via (location of ODL SDN controller)
ADVA	2x ETH switch 3x ROADM Reconfigurable Optical Add-Drop Multiplexer	Open SDN & NFV Lab, Berlin, Germany	Sendate-Cloud in Berlin, Germany
AltioStar	RRH Remote Radio Head	WinLab, NJ, USA	OWL-cloud (WinLab) in NJ, USA
Ceragon	Simulator	VM inside DT-Cloud, Prague, Czech Republic	DT-Cloud in Prague, Czech Republic
CommScope	DAS Distributed Antenna System	WinLab, NJ, USA	OWL-cloud (WinLab) in NJ, USA
DragonWave-X	6x MW devices 4x Horizon Compact Plus (HC+) 2x Horizon Quantum	Ottawa, Canada	DT-Cloud in Prague, Czech Republic
	2x MW devices	AT&T Lab, NJ, USA	AT&T-cloud in NJ, USA
Ericsson*	4x MW devices	WinLab, NJ, USA	OWL-cloud (WinLab) in NJ, USA
Intracom Telecom	2x MW devices OmniBAS OSDR ODU	Athens, Greece	DT-Cloud in Prague, Czech Republic
Nokia*	2x MW devices	AT&T Lab, NJ, USA	AT&T-cloud in NJ, USA
SIAE	2x MW devices AGS20 IDU split-mount	Milan, Italy	DT-Cloud in Prague, Czech Republic
ZTE*	2x MW devices	Tianjin, China	DT-Cloud in Prague, Czech Republic

Basic Architecture for ONF Proof-of-Concept Demo's

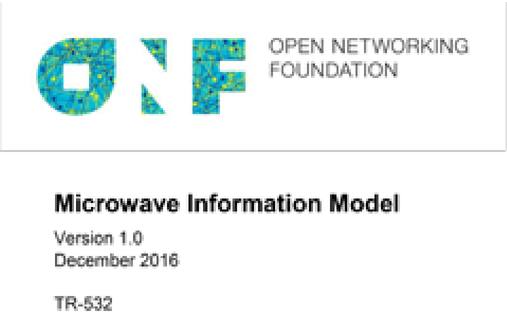
Multiple Vendors Share a Common Model of a Wireless Network Element



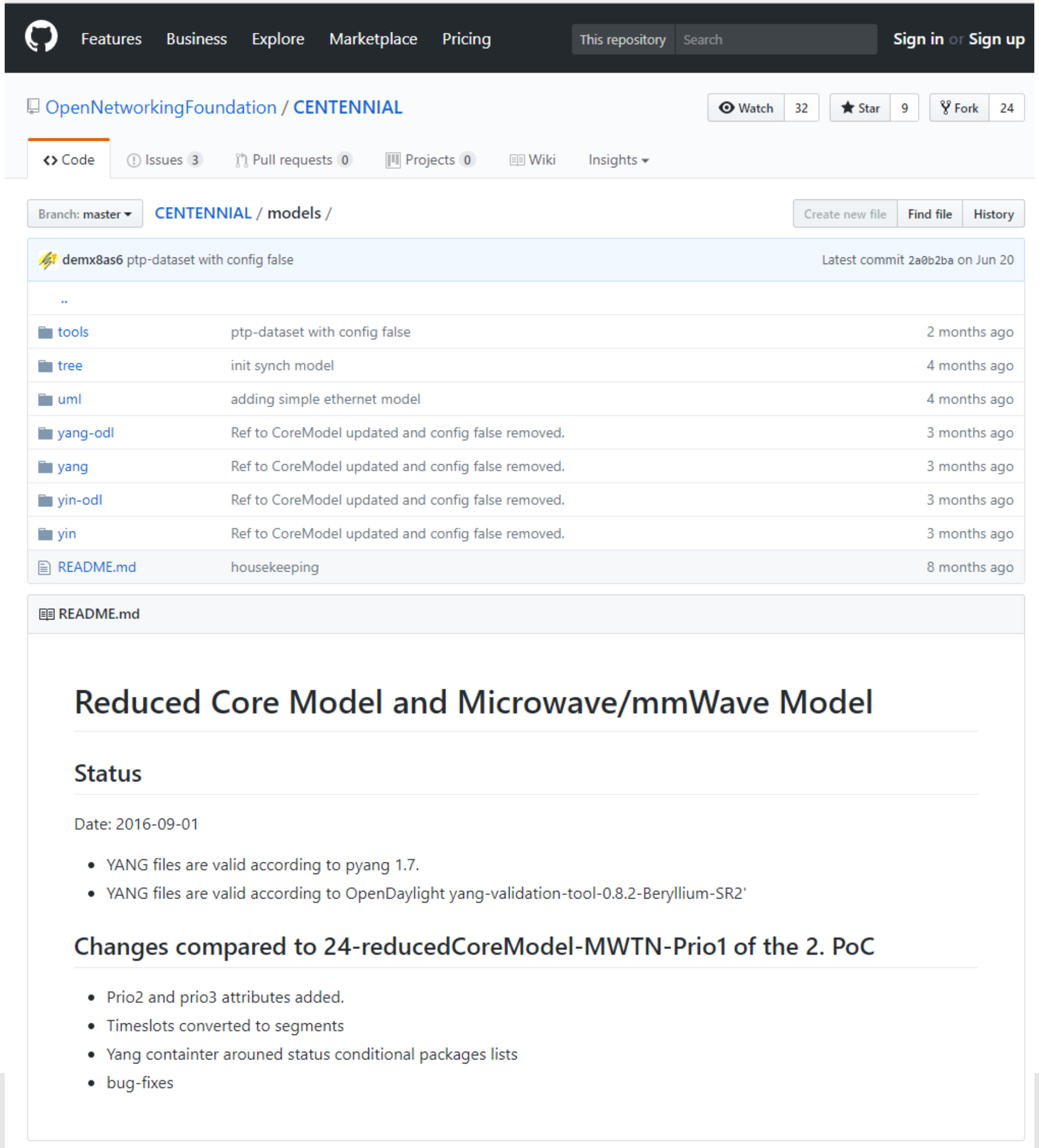
ODL Northbound REST API

NETCONF Southbound API

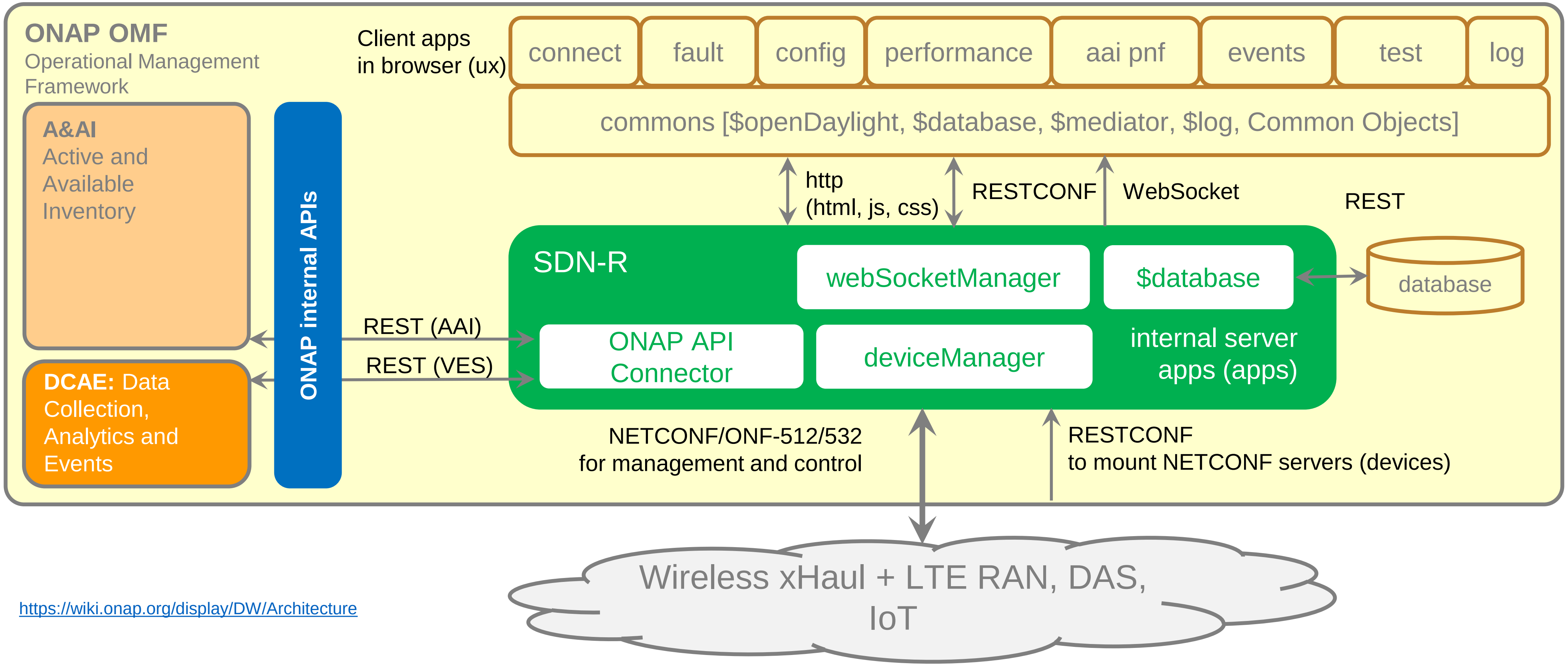
Common Information Model



ONF Technical Recommendation (TR) 532

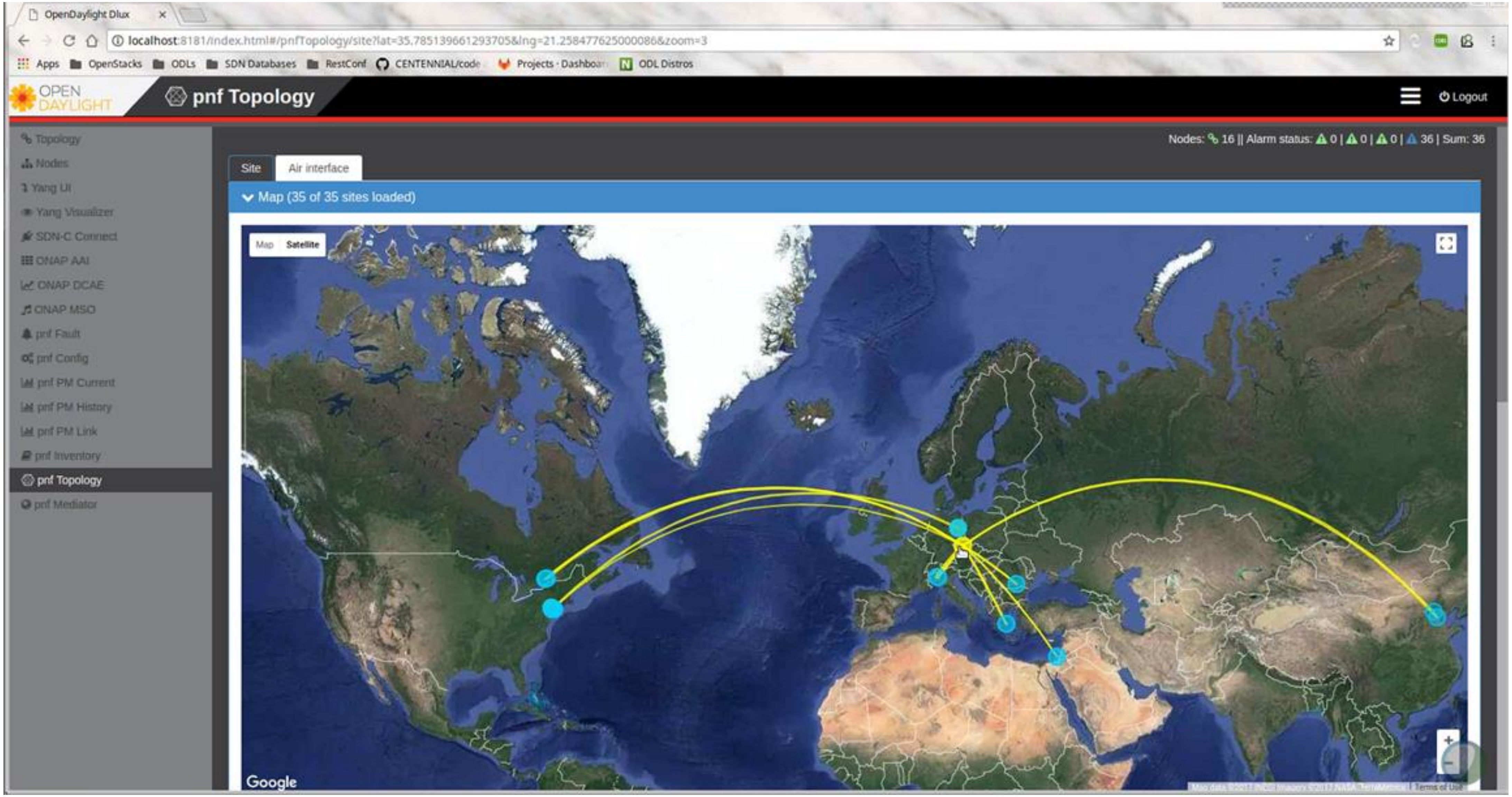


Simplified Architecture for ONF / ONAP Joint PoC

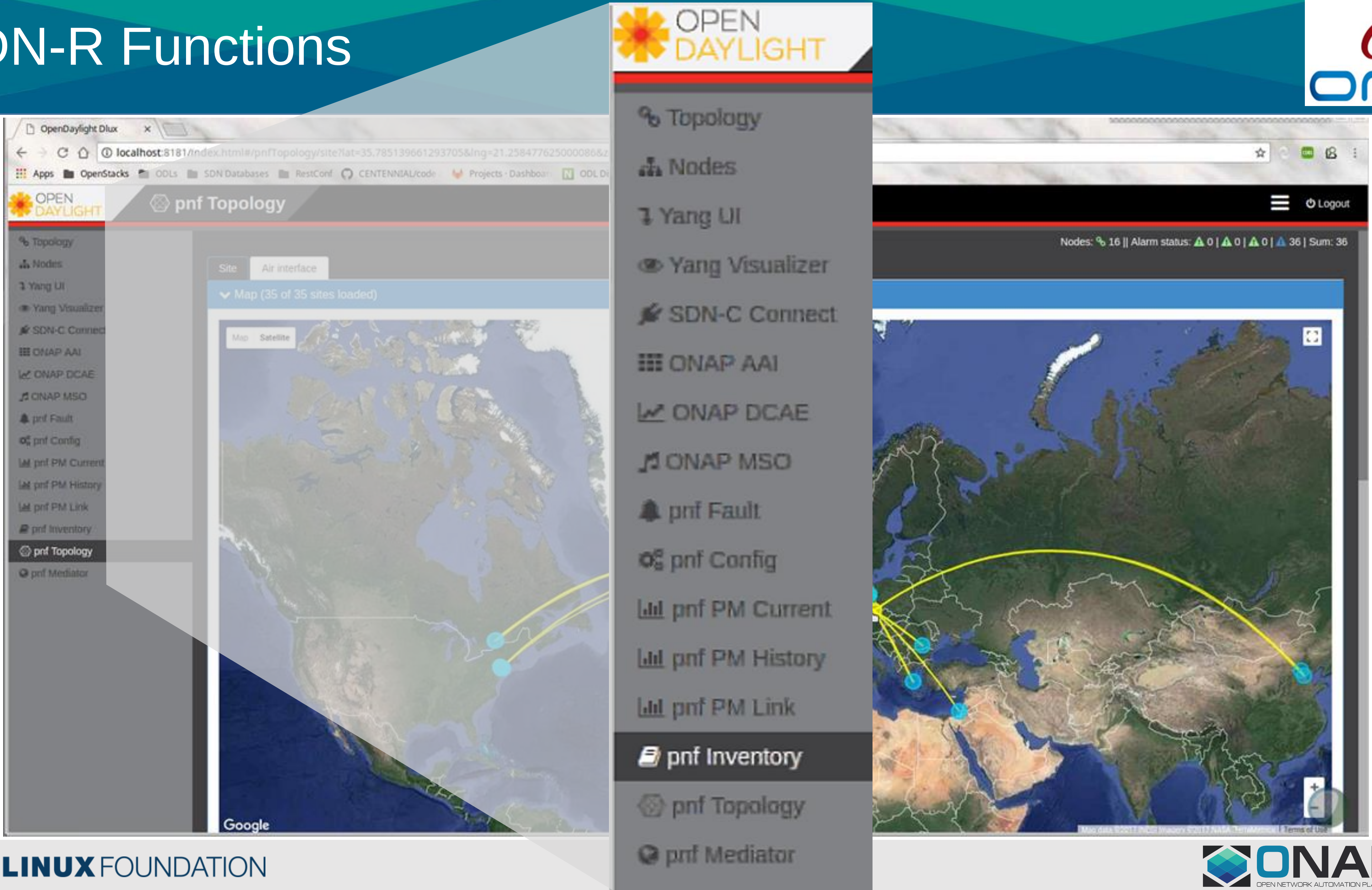


https://wiki.onap.org/display/DW/Architecture

SDN-R Web-based GUI Using OpenDaylight DLUX

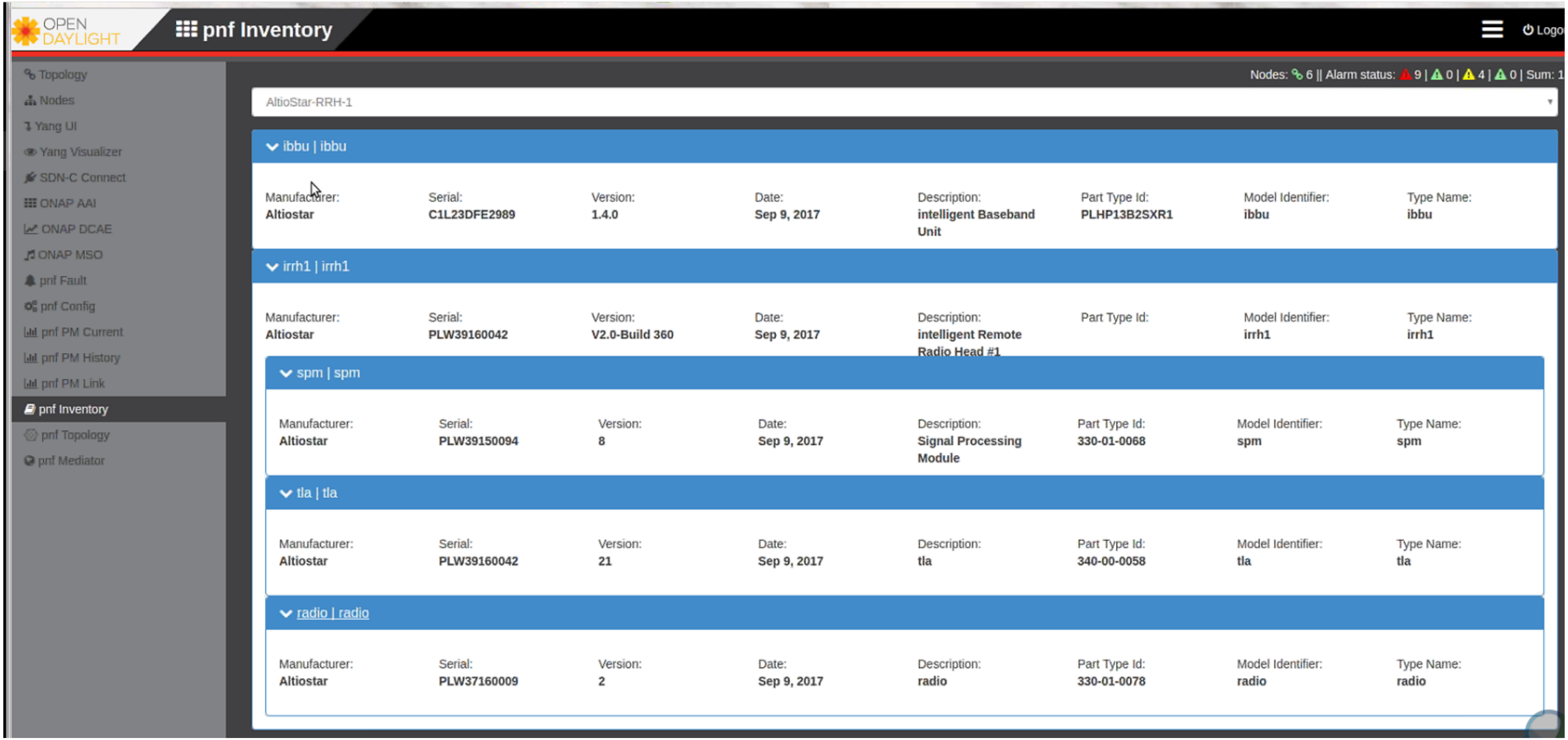


SDN-R Functions

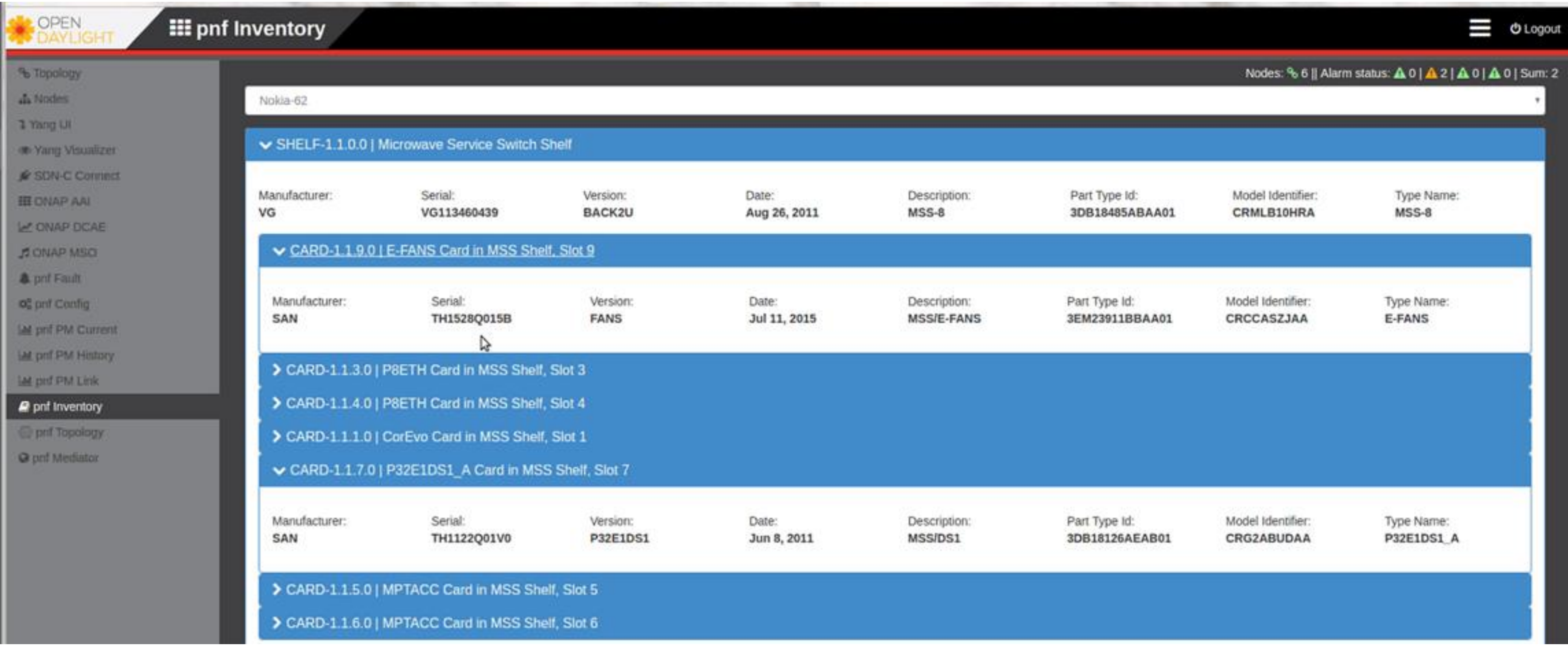


Inventory

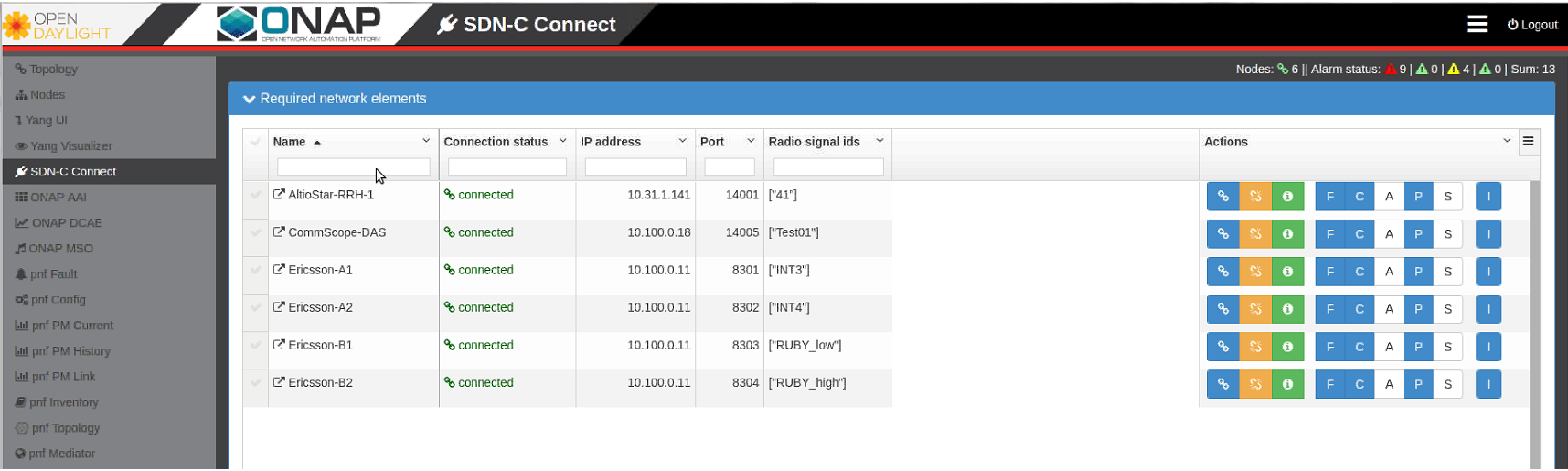
ONF



Drill Down to Components within a Network Element



NETCONF Connected Network Elements



ONAP Active and Available Inventory

OPEN DAYLIGHT

ONAP
OPEN NETWORK AUTOMATION PLATFORM

Active and Available Inventory

- Topology
- Nodes
- Yang UI
- Yang Visualizer
- SDN-C Connect
- ONAP AAI
- ONAP DCAE
- ONAP MSO
- pnf Fault
- pnf Config
- pnf PM Current
- pnf PM History
- pnf PM Link
- pnf Inventory
- pnf Topology
- pnf Mediator

ID	Name	Type	Vendor	Model	If OAM	Maintenan...
12345-123-12345-22	ADVA-ROADM-B	ROADM	ADVA	FSP 3000R7	10.20.4.12	false
192.168.2.33:14007	DragonWave-A3	WirelessTransport	DragonWav...	Horizon Quantum	0	false
192.168.2.33:14006	DragonWave-Z2	WirelessTransport	DragonWav...	Horizon Compact Plus	0	false
12345-123-12345-23	ADVA-ROADM-C	ROADM	ADVA	FSP 3000R7	10.20.4.13	false
10.10.240.53:4060	Quantum_FarEnd	Wireless Transport	DragonWave	Horizon Quantum	0	false
192.168.2.7:33002	SIAE-S2	WirelessTransport	SIAE	AGS-20	0	false
192.168.2.18:830	Intracom-A	WirelessTransport	Intracom	OSDR-13H13	0	false
10.10.235.10:40011	Nokia-62	WirelessTransport	Nokia	Nokia 7.1	0	false
192.168.2.51:830	ZTE-24	WirelessTransport	ZTE	ZXMW NR8120A	0	false
10.100.0.11:8303	Ericsson-B1	WirelessTransport	Ericsson	MINI-LINK 6352	0	false
12345-123-12345-21	ADVA-ROADM-A	ROADM	ADVA	FSP 3000R7	10.20.4.11	false
10.100.0.11:8304	Ericsson-B2	WirelessTransport	Ericsson	MINI-LINK 6352	0	false
192.168.1.4:13001	Ceragon-A1	WirelessTransport	Ceragon	Simulator	0	false
192.168.1.4:13003	Ceragon-Z1	WirelessTransport	Ceragon	Simulator	0	false
10.10.232.30:8307	Ericsson-23	WirelessTransport	Ericsson	MINI-LINK 6352	0	false
192.168.2.33:14005	DragonWave-A2	WirelessTransport	DragonWav...	Horizon Compact Plus	0	false

Total Items: 33

Established SDN-R as a Subproject of SDN-C

SDN-R Subproject

Subproject Name:

- SDN controller for Radio (SDN-R)

Subproject description:

The SDN-R subproject adds features/functionality to the OpenDaylight-based controller SDN-C (Core) that is built on the Common Controller Framework to configure and control wireless resources.

Scope:

The following features are in scope for the SDN-R subproject for ONAP release 2…

Community Labs in North America

TLAB	AT&T Advanced Technologies		Rich Bennett (RB2745@att.com) John Murray (JM2932@att.com)
Multi-Geo Labs via an IPSec GRE VPN tunnel	Wind River		Stephen Gooch (stephen.gooch@windriver.com)
WINLAB ONAP Wireless Lab (OWL)	Rutgers University/AT&T		Ivan Seskar (seskar@winlab.rutgers.edu) Tracy Van Brakle (tv8394@att.com)

WINLAB / ORBIT

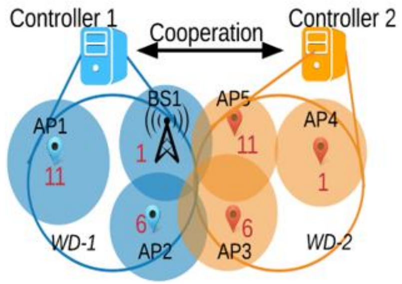
WINLAB Tech Center Facility

WINLAB founded in 1989 as a collaborative industry-university research center with specialized focus on wireless networking

~25 faculty/staff, most from the ECE and CS departments at Rutgers

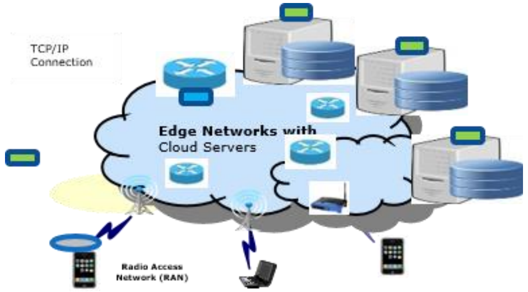
~40-50 grad students (80% PhD, 20% MS)

Center's research portfolio spans information theory, radio technology, wireless systems, mobile networks and computing



Dynamic Spectrum

Future Internet Arch.

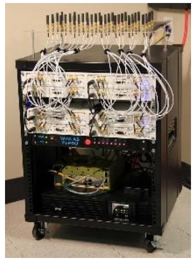


Edge Cloud

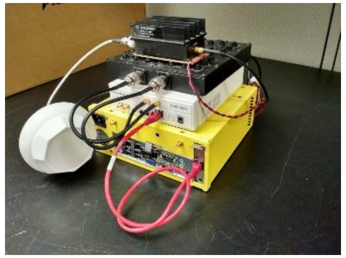
Connected Vehicle

Extensive experimental research infrastructure including ORBIT & GENI testbeds, SDR, SDN, …

Low Power IoT Device



Massive MIMO



SDR

ORBIT Radio Grid Testbed

GENI Rack

SDN

CloudLab Rack

Thank You!

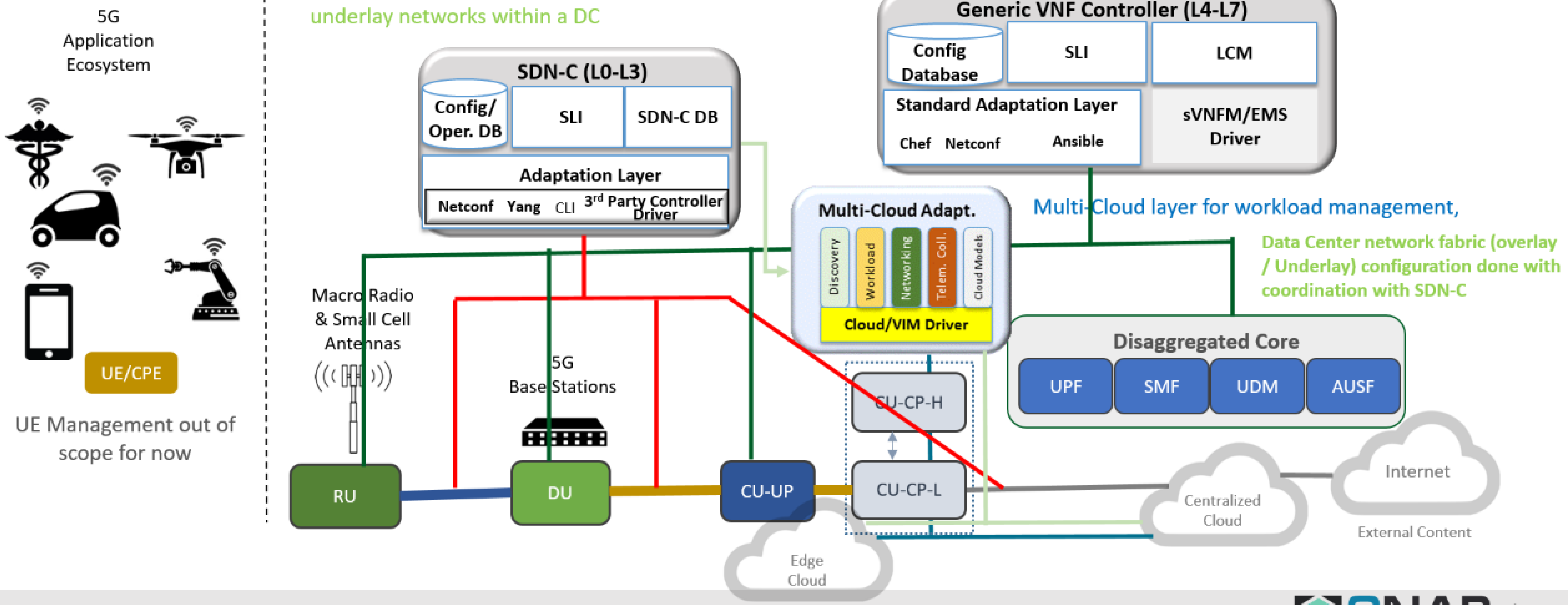
BACKUP SLIDES

Controller Scope to support anticipated 5G use cases

SDN-C (and possibly 3rd party controller) will be used for transport configuration – Front Haul, Mid Haul, Back Haul, etc.

Also, use multi-cloud layer to configure overlay & underlay networks within a DC

App-C (now Generic VNF Controller) is responsible for various network application configuration (PNF / VNF) – DUs, CUs, Disaggregated core, etc.



New Challenges in 5G Use Case

- Support a hybrid network consisting of PNF & VNF across RAN, WAN and EPC
- Support Design, Deploy, Monitor and Management of Network Slice(s)
- Design studio (SDC) enhancement
- Component models: e.g., RAN VNFs, Core VNFs, PNFs, etc.
- E2E model(s): e.g. service chain (tosca) topology, policy model(s)
- AAI enhancements to capture topology & inventory
- SO / App-C / DCAE / Policy enhancements to support for PNF and slice lifecycle management, slice deployment and management
- DCAE / Policy enhancements to support open framework for near-real time network optimization, conflict resolution during design time as well as run time across multiple microservices
- OOF enhancements to support multi-cloud and 5G network optimizations