◊ 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

ONF Board
ONF (& Stanford)  Guru Parulkar
Network Operators
AT&T  DT
Turk Telecom  Comcast
NTT Comm  Google
SK Telecom  Telefonica
Verizon
Research & Vendor Community
Nick McKeown  Stanford
Fabian Schneider  NEC

Operators

Innovator
SK Telecom
China Mobile
Chunghwa Tel
CENX
China Telecom
Juniper
Infinera
Others

Collaborator
70+
Volunteers
100s

Vendors

Volunteers

Microsoft
DoD
TELUS
Tencent
Vodafone
ZTE
Ceragon

AT&T
T
verizon
NEC
Cisco
Ericsson
Fujitsu
Samsung

Operators

AT&T
Turk Telecom
NTT Comm
SK Telecom
Verizon

AT&T
T
verizon

Research & Vendor Community
Nick McKeown  Stanford
Fabian Schneider  NEC

AT&T
Turk Telecom
NTT Comm
SK Telecom
Verizon

AT&T
T
verizon

Research & Vendor Community
Nick McKeown  Stanford
Fabian Schneider  NEC
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)
• Open APIs for network control are essential

ONF has defined Transport API (TAPI), and MEF has also adopted TAPI for their LSO Presto SDK

Common Network abstraction model

Common technological models

Open Transport API

Open MW API
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.

<table>
<thead>
<tr>
<th>Date + Sponsor</th>
<th>SDN controller and platform</th>
<th>ONF CoreModel (TRs 512 &amp; 532)</th>
<th>SBI protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st PoC; 4Q'15; Telefonica</td>
<td>ONOS</td>
<td>n/a</td>
<td>OpenFlow</td>
</tr>
<tr>
<td>2nd PoC; 2Q’16; Telefonica</td>
<td>ODL Lithium SR4</td>
<td>n/a</td>
<td>Netconf/YANG</td>
</tr>
<tr>
<td>3rd PoC; 4Q'17; AT&amp;T</td>
<td>ODL Beryllium SR2 (ECOMP)</td>
<td>CM 1.1</td>
<td>Netconf/YANG</td>
</tr>
<tr>
<td>4th PoC; 2Q’17; Deutsche Telekom</td>
<td>ODL Boron SR1 (ONAP release 0)</td>
<td>CM 1.2</td>
<td>Netconf/YANG</td>
</tr>
<tr>
<td>5th PoC; 4Q’17; AT&amp;T</td>
<td>ODL Boron / Carbon (ONAP “pre” Amsterdam)</td>
<td>CM 1.2</td>
<td>Netconf/YANG</td>
</tr>
<tr>
<td>6th PoC; 2Q’18 - TBD</td>
<td>ODL Nitrogen (ONAP Beijing)</td>
<td>CM 1.3</td>
<td>Netconf/YANG</td>
</tr>
</tbody>
</table>
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 $\rightarrow$ 1588v2, connection-oriented Ethernet with re-routing

- 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!
First Joint ONF/ONAP Demonstration with SDN-R

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

ONAP
AT&T TLAB ONAP CC
WinLab (OWL)

DT-Cloud
Prague, Czech Republic

Sendate-Cloud
Berlin, Germany

AT&T TLAB
Bedminster, NJ, USA

AT&T RF Lab
Midletown, NJ, USA

OWL-Cloud
WinLab, NJ, USA

Open SDN & NFV Lab, Germany

AT&T TLAB, NJ, USA

AT&T RF Lab, NJ, USA

WinLab, NJ, USA

SIAE, Italy

ZTE, China

Intercorn Tel., Greece

DWX, Canada

Coragon, Prague, Czech Rep.

simulator
<table>
<thead>
<tr>
<th>Vendor</th>
<th>Type of test devices</th>
<th>Location of test devices</th>
<th>Connected via (location of ODL SDN controller)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADVA</td>
<td>2x ETH switch</td>
<td>Open SDN &amp; NFV Lab, Berlin, Germany</td>
<td>Sendate-Cloud in Berlin, Germany</td>
</tr>
<tr>
<td></td>
<td>3x ROADM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reconfigurable Optical Add-Drop Multiplexer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AltioStar</td>
<td>RRH</td>
<td>WinLab, NJ, USA</td>
<td>OWL-cloud (WinLab) in NJ, USA</td>
</tr>
<tr>
<td></td>
<td>Remote Radio Head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceragon</td>
<td>Simulator</td>
<td>VM inside DT-Cloud, Prague, Czech Republic</td>
<td>DT-Cloud in Prague, Czech Republic</td>
</tr>
<tr>
<td>CommScope</td>
<td>DAS</td>
<td>WinLab, NJ, USA</td>
<td>OWL-cloud (WinLab) in NJ, USA</td>
</tr>
<tr>
<td></td>
<td>Distributed Antenna System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DragonWave-X</td>
<td>6x MW devices</td>
<td>Ottawa, Canada</td>
<td>DT-Cloud in Prague, Czech Republic</td>
</tr>
<tr>
<td></td>
<td>4x Horizon Compact Plus (HC+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x Horizon Quantum</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x MW devices</td>
<td>AT&amp;T Lab, NJ, USA</td>
<td>AT&amp;T-cloud in NJ, USA</td>
</tr>
<tr>
<td>Ericsson*</td>
<td>4x MW devices</td>
<td>WinLab, NJ, USA</td>
<td>OWL-cloud (WinLab) in NJ, USA</td>
</tr>
<tr>
<td>Intracom Telecom</td>
<td>2x MW devices</td>
<td>Athens, Greece</td>
<td>DT-Cloud in Prague, Czech Republic</td>
</tr>
<tr>
<td></td>
<td>OmniBAS OSDR ODU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nokia*</td>
<td>2x MW devices</td>
<td>AT&amp;T Lab, NJ, USA</td>
<td>AT&amp;T-cloud in NJ, USA</td>
</tr>
<tr>
<td>SIAE</td>
<td>2x MW devices</td>
<td>Milan, Italy</td>
<td>DT-Cloud in Prague, Czech Republic</td>
</tr>
<tr>
<td></td>
<td>AGS20 IDU split-mount</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZTE*</td>
<td>2x MW devices</td>
<td>Tianjin, China</td>
<td>DT-Cloud in Prague, Czech Republic</td>
</tr>
</tbody>
</table>
Basic Architecture for ONF Proof-of-Concept Demo’s

Multiple Vendors Share a Common Model of a Wireless Network Element

- OpenDaylight Controller
  - NETCONF southbound plugin
  - YANG model
  - internal app 1
  - internal app n

- External app 1
- External app n

- Mediator
  - NETCONF server
  - Vendor proprietary interface
  - YANG model

- Wireless network element 1
- Wireless network element n

- Mediator
  - NETCONF server
  - Vendor proprietary interface
  - YANG model

- eNodeB 1

- Mediator
  - NETCONF server
  - Vendor proprietary interface
  - YANG model

- eNodeB n

ODL Northbound REST API
NETCONF Southbound API
ONF Technical Recommendation (TR) 532

Reduced Core Model and Microwave/mmWave Model

Status
Date: 2016-09-01
- YANG files are valid according to yang 1.7.
- YANG files are valid according to OpenDaylight yang-validation-tool-0.0.2-Beryllium-SR2

Changes compared to 24-reducedCoreModel-MWTN-Prio1 of the 2. PoC
- Prio2 and puido attributes added.
- Timeslots converted to segments
- Yang container around status conditional packages list
- bug-fixes
Simplified Architecture for ONF / ONAP Joint PoC

**ONAP OMF**
Operational Management Framework

**A&AI**
Active and Available Inventory

**DCAE**: Data Collection, Analytics and Events

**Client apps in browser (ux)**
- connect
- fault
- config
- performance
- aai pnf
- events
- test
- log

**commons**
- $openDaylight
- $database
- $mediator
- $log
- Common Objects

**SDN-R**
- webSocketManager
- $database

**ONAP API Connector**
- deviceManager

**NETCONF/ONF-512/532**
for management and control

**RESTCONF**
to mount NETCONF servers (devices)

**WebSocket**

**REST**

**database**

Wireless xHaul + LTE RAN, DAS, IoT

[https://wiki.onap.org/display/DW/Architecture](https://wiki.onap.org/display/DW/Architecture)
SDN-R Web-based GUI Using OpenDaylight DLUX
### Inventory

#### AtlasStar-RRH-1
- **Manufacturer:** Altiostar
- **Serial:** C1L23D8E2989
- **Version:** 1.4.0
- **Date:** Sep 9, 2017
- **Description:** intelligent Baseband Unit
- **Part Type Id:** PLHP13B25XR1
- **Model Identifier:** ibbu
- **Type Name:** ibbu

#### irh1
- **Manufacturer:** Altiostar
- **Serial:** PLW39160042
- **Version:** V2.0-Build 360
- **Date:** Sep 9, 2017
- **Description:** intelligent Remote Radio Head 21
- **Part Type Id:** PLHE13B25XR1
- **Model Identifier:** irh1
- **Type Name:** irh1

#### spm
- **Manufacturer:** Altiostar
- **Serial:** PLW39150094
- **Version:** 8
- **Date:** Sep 9, 2017
- **Description:** Signal Processing Module
- **Part Type Id:** 330-01-0068
- **Model Identifier:** spm
- **Type Name:** spm

#### tla
- **Manufacturer:** Altiostar
- **Serial:** PLW39160042
- **Version:** 21
- **Date:** Sep 9, 2017
- **Description:** tla
- **Part Type Id:** 340-00-0058
- **Model Identifier:** tla
- **Type Name:** tla

#### radio
- **Manufacturer:** Altiostar
- **Serial:** PLW37160009
- **Version:** 2
- **Date:** Sep 9, 2017
- **Description:** radio
- **Part Type Id:** 330-01-0078
- **Model Identifier:** radio
- **Type Name:** radio
Drill Down to Components within a Network Element

<table>
<thead>
<tr>
<th>Component</th>
<th>Manufacturer</th>
<th>Serial</th>
<th>Version</th>
<th>Date</th>
<th>Description</th>
<th>Part Type Id</th>
<th>Model Identifier</th>
<th>Type Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHEL-1.1.0.0</td>
<td>VG</td>
<td>VG113464439</td>
<td>BACK2U</td>
<td>Aug 26, 2011</td>
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<td>3DB18465ABAA01</td>
<td>CRMLB10HRA</td>
<td>MSS-8</td>
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<tr>
<td>CARD-1.1.3.0</td>
<td>SAN</td>
<td>TH5329Q01S8</td>
<td>FANS</td>
<td>Jul 11, 2015</td>
<td>MSS/E-FANS</td>
<td>3EM2391BBA01</td>
<td>CRCASA2JAA</td>
<td>E-FANS</td>
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<td>CARD-1.1.4.0</td>
<td>Siemens</td>
<td>7H1327Q011Y0</td>
<td>P32E1DS1</td>
<td>Jun 8, 2011</td>
<td>MSS/D31</td>
<td>3DB18123AEAB01</td>
<td>CRG2ABUDAA</td>
<td>P32E1DS1_A</td>
</tr>
<tr>
<td>CARD-1.1.5.0</td>
<td>Siemens</td>
<td>7H1327Q011Y0</td>
<td>P32E1DS1</td>
<td>Jun 8, 2011</td>
<td>MSS/D31</td>
<td>3DB18123AEAB01</td>
<td>CRG2ABUDAA</td>
<td>P32E1DS1_A</td>
</tr>
<tr>
<td>CARD-1.1.6.0</td>
<td>Siemens</td>
<td>7H1327Q011Y0</td>
<td>P32E1DS1</td>
<td>Jun 8, 2011</td>
<td>MSS/D31</td>
<td>3DB18123AEAB01</td>
<td>CRG2ABUDAA</td>
<td>P32E1DS1_A</td>
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<td>MSS/D31</td>
<td>3DB18123AEAB01</td>
<td>CRG2ABUDAA</td>
<td>P32E1DS1_A</td>
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<tr>
<td>Name</td>
<td>Connection status</td>
<td>IP address</td>
<td>Port</td>
<td>Radio signal ids</td>
<td>Actions</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td>AltiStar-RRH-1</td>
<td>connected</td>
<td>10.31.1.141</td>
<td>14001</td>
<td>[&quot;41&quot;]</td>
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<tr>
<td>CommScope-DAS</td>
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<td>10.100.0.16</td>
<td>14005</td>
<td>[&quot;Test01&quot;]</td>
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<tr>
<td>Ericsson-A1</td>
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<td>8301</td>
<td>[&quot;INT3&quot;]</td>
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<tr>
<td>Ericsson-A2</td>
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<td>8302</td>
<td>[&quot;INT4&quot;]</td>
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<tr>
<td>Ericsson-B1</td>
<td>connected</td>
<td>10.100.0.11</td>
<td>8303</td>
<td>[&quot;RUBY_low&quot;]</td>
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<tr>
<td>Ericsson-B2</td>
<td>connected</td>
<td>10.100.0.13</td>
<td>8304</td>
<td>[&quot;RUBY_high&quot;]</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
## ONAP Active and Available Inventory

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Type</th>
<th>Vendor</th>
<th>Model</th>
<th>If OAM</th>
<th>Maintenan...</th>
</tr>
</thead>
<tbody>
<tr>
<td>12345-123-12345-22</td>
<td>ADVA-ROADM-B</td>
<td>ROADM</td>
<td>ADVA</td>
<td>FSP 3000R7</td>
<td>10.20.4.12</td>
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<tr>
<td>192.168.2.33:14007</td>
<td>DragonWave-A3</td>
<td>WirelessTransport</td>
<td>DragonWave...</td>
<td>Horizon Quantum</td>
<td>0</td>
<td>false</td>
</tr>
<tr>
<td>192.168.2.33:14006</td>
<td>DragonWave-Z2</td>
<td>WirelessTransport</td>
<td>DragonWave...</td>
<td>Horizon Compact Plus</td>
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<td>false</td>
</tr>
<tr>
<td>12345-123-12345-23</td>
<td>ADVA-ROADM-C</td>
<td>ROADM</td>
<td>ADVA</td>
<td>FSP 3000R7</td>
<td>10.20.4.13</td>
<td>false</td>
</tr>
<tr>
<td>10.10.240.53:4060</td>
<td>Quantum_FarEnd</td>
<td>WirelessTransport</td>
<td>DragonWave</td>
<td>Horizon Quantum</td>
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</tr>
<tr>
<td>192.168.2.7:33002</td>
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<td>SIAE</td>
<td>AGS-20</td>
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<tr>
<td>192.168.2.18:830</td>
<td>Intracom-A</td>
<td>WirelessTransport</td>
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<td>OSMR-13H13</td>
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<tr>
<td>10.10.235.10:4011</td>
<td>Nokia-62</td>
<td>WirelessTransport</td>
<td>Nokia</td>
<td>Nokia 7.1</td>
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<tr>
<td>192.168.2.51:830</td>
<td>ZTE-Z2</td>
<td>WirelessTransport</td>
<td>ZTE</td>
<td>ZXMW NR8120A</td>
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</tr>
<tr>
<td>10.100.0.11:8303</td>
<td>Ericsson-B1</td>
<td>WirelessTransport</td>
<td>Ericsson</td>
<td>MINI-LINK 6352</td>
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<td>12345-123-12345-21</td>
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<td>ADVA</td>
<td>FSP 3000R7</td>
<td>10.20.4.11</td>
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<tr>
<td>10.100.0.11:8304</td>
<td>Ericsson-B2</td>
<td>WirelessTransport</td>
<td>Ericsson</td>
<td>MINI-LINK 6352</td>
<td>0</td>
<td>false</td>
</tr>
<tr>
<td>192.168.1.4:13001</td>
<td>Cерагон-A1</td>
<td>WirelessTransport</td>
<td>Cерагон</td>
<td>Simulator</td>
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<td>false</td>
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<tr>
<td>192.168.1.4:13003</td>
<td>Cерагон-Z1</td>
<td>WirelessTransport</td>
<td>Cерагон</td>
<td>Simulator</td>
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<td>false</td>
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<tr>
<td>10.232.30:8307</td>
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<td>WirelessTransport</td>
<td>Ericsson</td>
<td>MINI-LINK 6352</td>
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<td>false</td>
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<tr>
<td>192.168.2.33:14005</td>
<td>DragonWave-A2</td>
<td>WirelessTransport</td>
<td>DragonWave...</td>
<td>Horizon Compact Plus</td>
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<td>false</td>
</tr>
<tr>
<td>102.168.2.33:14008</td>
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<td>WirelessTransport</td>
<td>DragonWave...</td>
<td>Horizon Quantum</td>
<td>0</td>
<td>false</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Community</th>
<th>Details</th>
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<tr>
<td>ONAP Wireless Lab (OWL)</td>
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<td>TLAB</td>
<td>AT&amp;T Advanced Technologies</td>
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<td>Multi-Geo Labs via an IPSec GRE VIPN tunnel</td>
<td>Wind River</td>
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<td>WINLAB</td>
<td>Rutgers University/AT&amp;T</td>
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WINLAB / ORBIT

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

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

Dynamic Spectrum  Future Internet Arch.  Edge Cloud  Connected Vehicle

Low Power IoT Device  Massive MIMO  SDR  ORBIT Radio Grid Testbed  GENI Rack  SDN  CloudLab Rack
Thank You!
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.

Multi-Cloud layer for workload management,

Data Center network fabric (overlay / Underlay) configuration done with coordination with SDN-C

UE Management out of scope for now
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