Transport SDN in ONF

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March 14, 2016
Content

- Introduction and Drivers
- Use Cases & Applications
- Architectures & Interfaces
- Activity and Projects in ONF

We will mainly look at SDN from a Transport perspective …
What we see in the market?

A New Kind of Business Customer
- Private and public cloud
- Elastic compute and storage

A New Kind of Consumer
- Living in the cloud
- Streaming Downloads
- Driving new network loads

A New Network is Required
- Bandwidth-on-demand to match the compute/storage on-demand technology
- Multi-tenant
- Higher utilization, greater efficiency
- Scalable and resilient
- Faster service deployment
## Transport Use Cases – Network Perspective

<table>
<thead>
<tr>
<th>Carrier’s Carriers</th>
<th>Mobile Backhaul</th>
<th>Data Center Interconnect</th>
<th>Global Tier 1/2/3 Networks</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Carrier’s Carriers" /></td>
<td><img src="image2.png" alt="Mobile Backhaul" /></td>
<td><img src="image3.png" alt="Data Center Interconnect" /></td>
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### Different Network Requirements

<table>
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<tr>
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<td>Changing bandwidth</td>
<td>High number of vendors</td>
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<td>Complex networks</td>
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<td>Number of Vendors</td>
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<td>Business/Operational boundaries</td>
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Transport Use Cases – Service Perspective

**Service Management**
- Automated service creation covering L0 to L3
  - Addressing
    - Time to service
    - Ease of operation
    - Service differentiation

**Elastic bandwidth provisioning**
- Creation of elastic services with automatic or “on request” changes in bandwidth
  - Dealing with
    - Statistical bandwidth sharing
    - Dynamic data flow changes

**Datacenter interconnections**
- Automatic load dependent fast service creation
  - Matching
    - Hypergrowth in data volume
    - Extremely dynamic traffic pattern

**Network or Transport as a Service (NaaS / TaaS)**
- Fully automate service requests incl. network planning and equipment configuration
  - Addressing
    - Non-automated Operational processes
    - High network complexity

**Multi-layer network management**
- Multilayer optimized L0-3 system with
  - common workflows
  - automatic routing
  - interworking
  - Dealing with
    - Heterogeneous technologies
    - Optimized layer usage

**Multi-vendor support**
- One standardized SDN control interface for easy integration of 3rd party vendors
  - Dealing with
    - Different control interfaces
    - Missing control IF between vendors
Transport Use Cases – Technology Perspective

Different Network Requirements

- High number of services
- Complex network
  - Numerous Protocol
  - Legacy infrastructure
  - Difficult to change / migrate
- Newer technology – very high flexibility
  - Complex services (e-line, e-tree, e-лан, e-access)
  - Interworking with IP domain
  - Will have high number of services
- High number of services
  - Too much flexibility
  - Complex service types
- High number of services
  - Switching complexity
  - Deterministic Protection / Restoration
- Complex Technology – optical impairments on fiber
  - New flexibility with color-/directionless architectures
  - High bandwidth / slow switching times
What are operator challenges for Transport networks?

- Tremendous increase in complexity
  - More and more traffic
  - More and more layers & protocols
  - Changing traffic pattern
  - New Application (e.g. DC)
  - Multiple Vendors

SDN addresses these ideas
What are the vendor challenges?

- High cost pressure
- Less distinguishing HW features
- High coast on protocol development
- Need innovative feature set

SDN enables new approaches
Transport Use Cases – Business Perspective

How to maximize revenue?

- Save OPEX
- Save CAPEX
- Generate new business through innovation
Content

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• Use Cases & Applications
• Architectures & Interfaces
• Activity and Projects in ONF

We will mainly look at SDN from a Transport perspective …
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
Use Case: Multi-Layer (Packet-Optical) Management

Current Situation:
- Service creation is done in different domains separately
- Routing is optimized for one layer only and does not consider behaviour of other layers

SDN:
- Controller shields complexity of the network towards orchestrator
- Orchestrator gets abstracted and simplified view on the network
- Orchestrator coordinates routing over several layers and can consider e.g.:
  - Topology & SLRG
- Optimization over several layers for equipment and link utilization can be considered
Use Case: Bandwidth on Demand

• Application
  – Creation of new service through online portal
  – Change topology (end-point) configurations
  – Change service parameters. E.g.
    » Add/remove/change service classes
    » Modify bandwidths (possibly per service class)

• Business Benefits
  – A new type of service offering
  – Meets market demand
  – Differentiator
  – Self-service can reduce operations costs

• Requirements
  – Introduction of User SDN-controller/orchestrator
  – Application / Portal Software
  – Engineering rules and / or user policy

• Often a first step towards dynamic service
  – Visual
  – Unique capability
  – …quickly becoming a requirement
Use Cases around Data Center

There are different areas where SDN can help:

1. In the Data Center to optimize local infrastructure & to interwork with NFV
2. Between clients and the Data Center to secure bandwidth
3. Between Data Center to establish new bandwidth or scheduled bandwidth e.g. for backup tasks
Datacenter Interconnect Use Case

• Open Multi-Vendor, Multi-Layer interfaces
• Example
  ONF TAPI - Topology, Connectivity
  ONF - OpenFlow 1.3
Options for Multi-layer Service Restoration

Restoration interfaces and application

Two options for service restoration in an SDN architecture

• Controller has integrated restoration functions for restoration inside a domain. Rerouting happen according the pre-defined SLA parameter in the network. **Advantage:** Restoration is fast and simple (parameter of the service from application point of view)

• Orchestrator based rerouting - use the standard ONF Transport API interface. Will be used mainly for multi domain / multi-layer restoration e.g. in combination with protection as of speed. **Advantage:** complex restoration scenarios possible over multiple-domains (vendors) with customer specific behaviors
Use Case: E2E Service Restoration

Current Situation:
- Service creation done in domains separately
  - Router
    » FRR, 1:1 LSP, LAG, etc...
    » Service: PWE3
  - Och
    » 1+1 / Ring (protection path reserved)
    » NMS, GMPLS setup

SDN:
- Multi-layer view on the network
- Consideration current state of network for service restoration:
  - Free resources
  - multiple layers
  - Error on other layers
  - SLRG
- Restoration according required SLA
- New resilience classes for services
Use Case: Multi-Layer Service Restoration – Service Classes

Service SLA-based restoration
• Premium services SLA = Premium price
• Avoid over-protection of non-SLA services

Requirements:
• Multi-layer PCE/routing
• Multi-layer visibility

Business Benefits:
• Improves network utilisation
  – Avoids over-provisioning
• Reactive SLA-based pricing
  – Enable Premium pricing

<table>
<thead>
<tr>
<th>Level</th>
<th>Restoration SLA</th>
<th>Network Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>&lt; 50 ms</td>
<td>• OCh: 1+1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• L2/L3: PWE3/FRR, etc</td>
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<tr>
<td></td>
<td></td>
<td>• Access: Diverse</td>
</tr>
<tr>
<td>Silver</td>
<td>&lt; 10 Sec</td>
<td>• OCh: Unprotected</td>
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<tr>
<td>Bronze</td>
<td>None</td>
<td>• OCh: Unprotected</td>
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Use Case: Combined Restoration and Protection

Use case description:
1. 1:1 LSP protection with disjoint LSP paths in the MPLS-TP and IP-MPLS domains
2. When working path fails traffic switches to protection
3. Disabled path is deleted
4. New protection path is calculated by the SDN controller
Use Case: MPLS-TP / IP-MPLS stitching

MPLS-TP Domain          IP-MPLS Domain

SDN Applications
Orchestrator
Transport Controller
IP Controller

Label stitching
Use Case: Congestion Control

**Use case description:**

1. Congestion is monitored by SDN application – network wide (!)
2. When congestion is detected, lower QoS services are redirected to links with available capacity
Use Case: Core Router Interworking

- Core routers connected via \( n \times \text{lambda} \)
- Low utilization of this links & router interfaces today
- Interworking IP/Transport are manually (phone/paper) => very slow

New:
- Put unused resources in pools
- Hibernate Transponders for max power saving
- Manage router & Transport via SDN
- Fast service changes as of automated interfaces in SDN
  - traffic pattern changes
  - errors (e.g. fiber breaks)
  - maintenance
Use Case: Equipment Utilization & Planning

Current Situation:
- Feedback from equipment installed in the network via proprietary interfaces & solutions
- No real time feedback => slow and faulty processes
- Services are created over physical existing equipment only
- No abstracted view – feedback shows real equipment which is vendor specific.
- Unutilized equipment or bottlenecks on links or equipment can not be recognized

SDN:
- This use case is in scope of several operators
- Would solve a real issue of operators
- Currently not considered in SDN standardization
- Get a simplified view on resource utilization on top layer to identify:
  - Unused equipment
  - Resource/Link utilization
- Creation of services over planned (not physical existing) equipment to reserve future resources (plug & play)
Software Defined Optics (SDO) – SDN for Flexible Photonic System

Current optical network
- Colored, directional ROADM
- Fixed channel grid
- Fixed format transponder
- Fixed routing

Software-defined Optical Network
- CDC multi-degree ROADM
- Flexible channel grid
- Variable format transponder
- Impairment-aware routing

A Flexible Transport Plane (SDO), with:
- Multi-degree variable super-channel transponder:
  - Multiple optical subcarriers – different flows to different destinations
  - Independently adjustable modulation format, power level, FEC coding, etc.
  - Multi-degree flex-grid wavelength cross-connect:
    - allows programmable CDC switching on fine grid WDM channels, etc.
  - Adaptive hybrid amplifier:
    - deliver optimum power level based on traffic needs with energy efficiency.

Intelligent Control Plane for cross-network optimization:
- Monitors the physical condition changes.
- Configures flexible optical hardware to achieve optimal utilization and spectral efficiency.
- Interacts with the packet SDN controller (which monitors the network traffic and provides information of new demands) for joint network optimization.

Open Interfaces for common control of multi-vendor NW...
**Flexible Modulation Formats**

- **Shorter distance** → Higher modulation level → Higher spectral efficiency → Higher capacity
- **Lower data rate** → Lower modulation level → Better impairment tolerance → Longer distance

**Flexible Subcarriers in Superchannel**

- **Less data** ↓ Fewer subcarriers ↓ Less spectrum required, lower power consumption
- **Higher data capacity per channel** ↑ More subcarriers ↑ More spectrum available

**Flexible Channel Spacings**

- **Shorter distance** ↓ Closer channel spacing ↓ Higher spectral efficiency ↓ Higher capacity
- **Longer distance** ↑ Less crosstalk ↑ Larger channel spacing ↑ Lower data rate

**Flexible FEC Codings**

- **Shorter distance/less impairment** ↓ Weaker/lower overhead FEC coding ↓ Higher capacity
- **Longer distance, better impairment tolerance** ↑ Longer/stronger FEC coding ↑ Lower data rate

- Data
  - FEC
  - O/H
SDO in Photonic Switching

**Colorless:** Any wavelength can be dropped to or added from each transponder.

**Directionless:** Any transponder can receive signal dropped from any input degree, and can add signal to any output degree.

**Contentionless:** Signals with same wavelength can be added/dropped to/from different inputs simultaneously.

**Gridless:** Different channels can occupy different amount of optical spectrum bandwidth concurrently, and these bandwidths can be changed dynamically.

**Filterless:** Each transponder can pick the target WDM channel from multiple WDM channels without using demultiplexer or filter.

**Gapless:** WDM channels that will be switched to the same destination are grouped into wavebands to reduce filtering effect and reduce switching elements.
SDO in RWSA: Routing, Wavelength & Spectrum Assignment

Impairment-aware Routing

Variable Format Transceiver Flex Grid

QPSK: high OSNR tolerance

Long distance

Impairment-aware

Variable Rate Transceiver

- High capacity with multiplexing multiple optical subcarriers
- High spectrum efficiency with dynamic number of subcarriers

1Tb signal

800Gb Optimized

CDC Multi-degree ROADM

Failure

Example: On short distance working path, high level code modulation results in higher spectrum efficiency. On protection path that is long distance, modulation format is changed to low level code for high OSNR tolerance.
We will mainly look at SDN from a Transport perspective …
SDN & Related Areas

- Data Center/Enterprise SDN
- Transport (Packet + Optical) SDN
- Network Function Virtualization
Data-Center/Enterprise SDN versus Transport SDN?

**Data Center/Enterprise SDN**
- SDN principles applied to packet networks
  - Layer 2 (ETH)
  - Layer 3 (IP/MPLS)
- History:
  - Campus networks – research of new protocols
  - Frustration of device SW changes for any new function
- Relatively Mature
  - SDN ideas solidified ~ 2008
  - First ONF OpenFlow specs in 2009
  - OpenFlow interface widely deployed (1.3.x)

**Transport SDN**
- SDN principles applied to transport networks
  - Layer 0 (optical)
  - Layer 1 (OTN)
  - Layer 2 (Carrier ETH)
  - Layer 2.5 (MPLS-TP)
- History:
  - Fast service setup required as of high bandwidth demand
  - New technologies introduce flexible optical layer
  - Operator to solve integration problems
  - ONF OTWG Openflow for Optical (1st release available)
  - ONF Transport APIs – YANG/JSON (draft available today)
  - 2014 interoperability tests in several vendor labs done
It takes me **too long to deploy new services**
- New services require a new Protocol or Device
- Constrained by Vendors – procure, design, integrate, deploy, cycle

My network is **difficult to operate**
- Too complex
- High number of new protocols
- Protocol test needed between vendors
- New standards increase cost / decrease stability
- Don’t touch! You’ll break it!

My network has a **mind of its own**
- Current protocols are distributed and make local decisions rather than network wide
- Distributed protocols are not optimized for end-to-end and layer-to-layer
- Congestion control is hard with distributed management planes
- Lack of traffic visibly
Traditionally the transport networks are more static

- Traffic growth and higher layer applications flexibility was not strong driver in transport
- Focus was more on stability and quality
- Robust engineered networks, typically for peak capacities
- Architectures traditionally couple of layers
  - Electrical SDH layers had some limited flexibility
  - Optical layers have been totally static in past
- Expensive OSS integration of number of vendors domains

Modern transport networks are required to be more dynamic

- Packet optical devices & introduction of ETH/MPLS-TP
- Optical switching with new optical technology e.g. CDC, FLEX-Grid ROADM
- Hyper-growth transport capacity demands
- High price pressure requires operators to optimize and focus on new business
  - Application focused – programmable – automation
  - OPEX reduction a must
Why do we need SDN in Transport?

**Principles of SDN**

- **Programmability:**
  - Programmable interfaces
  - Applications focused architecture
  - Abstraction & Virtualization
  - Multi-Tenant capabilities

- **Openness:**
  - Open Standards & Interfaces
  - Open Source SW

- **Integration focused:**
  - Multi-layer
  - Multi-vendor

**What it Enables in Transport Network**

- **Innovation:**
  - Opens doors for new service models
  - Service differentiation through new application

- **Simplified Architectures:**
  - Integrated E2E / Multi-layer service creation
  - Automatic reaction on errors or any changes

- **Financial Benefits:**
  - Opex: efficient service setup
  - Capex: fast ROI / hardware utilization
  - New revenue opportunities
Is T-SDN different from traditional architectures?

**Traditional Architecture**

- OSS/BSS/App Systems
- NMS/EMS
- NE

**SDN Architecture**

- Apps
- SDN Controller
- NE

**The difference is NOT:**

- Standardized Management Interfaces
- Standardized Architecture
- Partly not the Open Interfaces
- Partly not even the use cases

**The difference is:**

**A new way of thinking**

- Application focused architecture and interfaces
- Application takes control over the service definition and delivery at faster time scales
- Simplification through Abstraction & Virtualization
- Open Source based platforms & development
Where does Transport SDN fit in? The Big picture…
Where does T-SDN fit in? E2E Network Architecture

1. Data Center SDN
2. NFV (Network Functions Virtualization)
3. SDN Transport
4. Operations & Orchestration
2014 OIF-ONF Transport SDN Interop Demo
ONF Transport – API & Interfaces: Functional Architecture

- Application
- SDN Controller
- Transport API
- Topology Service
- Connectivity Service
- Path Computation Service
- Virtual Network Service
- Notification Service
- Shared Network Information Context
- Network Resource Groups
- SBIs (e.g. Openflow Optical)
- SDN Controller

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ONF Open Transport WG (OTWG) – At a Glance

- Charter: The Open Transport project will address SDN and OpenFlow® Standard-based control capabilities for transport technologies
  - Including Optical and Wireless
  - Identifying/addressing Use Cases
  - Application of SDN Architecture
  - Information Modeling of transport NW
  - Defining standard SDN Interfaces for transport network controllers
    - OpenFlow® protocol extensions
    - SDN Controller Transport APIs.
- WG Chair: Lyndon Ong
- Vice Chairs: Karthik Sethuraman, Maarten Vissers, Vishnu Shukla

- Biweekly calls: Tuesday 6am US PDT
- opentransport@login.opennetworking.org
- Sub-projects:
  - Architecture – Maarten Vissers
  - Information Model – Kam Lam
    (weekly calls Tuesday 5am US PDT)
  - Transport APIs – Karthik Sethuraman
    (weekly calls Monday 6am US PDT)
  - OpenFlow Protocol – Lyndon Ong
    (bi-weekly calls Tuesday 6am US PDT)
  - Wireless Transport – Ariel Adam
    (bi-weekly calls Tuesday 6am US PDT)
  - Snowmass OSSDN project – Karthik
  - Englewood OSSDN project – Italo Busi
ONF OTWG Publications and Deliverables

- **Openflow Optical Extensions**
  - TS-022
  - Published as a separate extension document to core Openflow Spec

- **Optical Transport Use cases**
  - TR-509

- **Requirements Analysis for Transport OpenFlow/SDN**
  - TR-508

- **Openflow-enabled Transport SDN solution brief**
  - Jointly with ONF-MEC

- **Transport SDN Architecture (TR)**
  - In ONF-review/approval process

- **2014 OIF-ONF Joint Prototype Interop**
  - 9 Vendors, 6 Carriers
  - Pre-standard Openflow Optical, T-API

Current/near term activities, projects, documents

- **Openflow Optical Extensions v1.1** – (Q2 2016)
- **Transport API v1.0** – (Q2 2016)
  - Functional Requirement Spec (FRS)
  - UML Info Model, YANG/JSON Schema
  - Swagger API, Python Stubs
- **Wireless/RAN Transport** – (2Q 2016)
  - PoC: UML Info Model, YANG Schema
  - Openflow based PoC completed last year
- **Information Model** – (2Q 2016)
  - Technology specific fragments to ONF CIM
  - L0/L1 (OTN), L2 (Carrier Ethernet, MPLS-TP)
- **OIF-ONF Transport SDN Interop** (Q3 2016)
- **Next Interim meeting June 13-17**
  - Shenzhen, China (ZTE sponsor)
OTWG Optical Extensions: Key Issues Addressed

- Standardized extensions to OFP 1.3/1.4+
- Allows control of L0/OCH (optical channel) and L1/ODU (electrical timeslot) switching
- New OpenFlow port types
  - OTU, OPS, OTS, OMS, OCH
  - Optical port capabilities including client signals
- New Match fields
  - Optical Channel Frequency and slot width for L0
  - Signal type and tributary slot map for L1
  - Uses Set-Action to rewrite label fields
- Support of L0/L1 Adjacency Discovery
  - Reference standardized L0/L1 data-plane discovery signaling mechanisms (TTI, etc)
  - OF extensions to provision discovery labels and report mismatches/results
- Guidance on use of OF mechanisms for optical transport (e.g. timeouts, flags)

Benefits and Goals

- Enables usage of OpenFlow-based SDN in Optical Transport Networks
- Multilayer integration using OpenFlow protocol across all layer networks
- Unified control of packet-optical converged transport devices using OpenFlow
- Validated technically
  - Prototyped and tested in 2014 OIF/ONF demonstration
  - Prototyped and released in ONOS December open source code
OFP-based control of Converged Packet-Optical NEs

- Packet-Optical converged network devices
  - IP/MPLS(-TP), ETH, ODU, OCH switching
  - Openflow – Optical MAT extensions
    - ODU/OCH match fields, OF optical ports
  - SDN-based forwarding/routing control logic
  - Multi-layer Network/Switch Information Model
### OTWG Optical Extensions: Next Steps

#### Short Term Work Items
- Draft targeted for quick release (2016Q1)
- Cleanup structure and format of the port extensions TLV
- Usage of a code point for Optical Port type rather than experimenter
- Support existing Optical port extensions in OF 1.4 as OTWG photonic layer
- Additional Optical port types/layers (OTN Client ports) and attributes
- Corrections, clarifications, additional examples to v1.0 spec

#### Longer Term Work Items
- Worked on in parallel – (2016Q2)
- Support for fixed cross-connections
- Connectivity constraints
- Multilayer adaptation control
  - based on EXT-112 and 382
- OAM/monitoring
  - Autonomous Function based on EXT-548
- Protection
  - Autonomous Function or other mechanism
- Wireless extensions
  - Likely to be a separate spec
- Programmable OTN (Onf2015.453)
  - Likely to be whitepaper or use case

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Transport API Project Overview

• **Objective** – realize the software-centric approach to standardization
  - Purpose-specific API to facilitate SDN control of Transport networks
  - Focus is on functional aspects of transport network control/mgmt
  - Target is YANG & JSON API libraries
  - Demonstrable code

• **Activity** scoped based on use case contributions and discussions. Examples include
  - Bandwidth on Demand
  - E2E Connectivity Service
  - Multi-layer Resource Optimization and Restoration
  - Multi-Domain Topology and Monitoring
  - Network Slicing and Virtualization

• **Topology Service**
  - Retrieve Topology, Node, Link & Edge-Point details

• **Connectivity Service**
  - Retrieve & Request P2P, P2MP, MP2MP connectivity
  - Across (L0/L1/L2) layers

• **Path Computation Service**
  - Request for Computation & Optimization of paths

• **Virtual network Service**
  - Create, Update, Delete Virtual Network topologies

• **Notification Framework**
  - Subscription and filtering
  - Autonomous mechanism
TAPI - High Level Weekly Work Flow

- **Use cases** – describes concepts and API usage
  - Presentation Slide decks, Contributions welcome
- **Functional Requirements**
  - Word doc – onf2015.087.* - last call draft in progress
- **Information Model**
  - Develop API-specific UML model (Papyrus tool)
  - Based on and extends ONF Core IM
- **Data Schema & API**
  - Develop YANG/JSON schema encoding
  - Generated from API IM using OSSDN EAGLE tools
  - Swagger API/Python code generated from YANG schema
- **Software Prototyping**
  - Separate project under ONF Open Source SDN
- **Follow “Agile” development and “fail-fast” processes**
  - Work on all items (Req, IM, API) in parallel
TAPI Coordinates

• Single 2-hour weekly working-level call
  – Work on all aspects of T-API
  – Status reporting in the OTWG biweekly Tuesday 6 AM call
• Transport API weekly working-level call
  – Mondays, 6 AM US Pacific Time
  – https://onf.webex.com/onf/j.php?MTID=m4d6b2de664e9c5d76a4de49ca479ce22
• ARO Project Resources and Mailing List
  – transport-api@login.opennetworking.org
  – https://login.opennetworking.org/bin/c5i?mid=3&rid=5&gid=0&k1=24&tid=1420463562
• OSSDN SNOWMASS/Open Transport API Specification - drafts
  – UML Info Model, YANG Schema, JSON Schema, Swagger API
  – https://groups.opensourcesdn.org/wg/SNOWMASS/dashboard
  – https://github.com/OpenNetworkingFoundation/ONFOpenTransport
• OSSDN ENGLEWOOD - Open Transport API Prototyping
  – https://groups.opensourcesdn.org/wg/ENGLEWOOD/dashboard
Functional Requirements last call draft will be socialized for ONF-wide review and will be available publicly for comments and feedback
  - Targeted towards early 2Q 2016 release

API drafts to be posted and regularly updated on the ONF Github site
  - Information Model (UML), Data schema (YANG, JSON, Swagger)
    - https://github.com/OpenNetworkingFoundation/ONFOpenTransport

Next version – planned for 2016Q2-end – around ONF Interim meeting
  - Enhance Virtual Network Service features
  - P2MP, MP2MP Connectivity Service Use cases
  - Protection and OAM Support
  - Optical, Packet & Wireless Transport technology layers spec-models
    - WDM, OTN, Carrier Ethernet, MPLS-TP

Closely working with the ONF-IMP (Information Modeling Project)

Coordinating with OIF for the 2016 Transport SDN Interop Demo which will use ONF T-API

Coordinating with MEF to align with LSO-NRP (Network-Resource) information model

A sub-group in ONF working on a IETF informational draft comparing TEAS Topology with T-API Yang output

Working with OASIS/TOSCA to define templates for orchestration of T-SDN

Network Interface in the proposed OSSDN CSO - Cross Stratum Orchestration project
Demonstrated bandwidth-on-demand application and end-to-end service orchestration in a multi-domain environment

- 5 carriers, 9 vendors
- Intra-carrier lab and Inter-carrier lab testing

Architecture

- **Domain Controller** – Controls vendor domain networks – generally provided by NE vendor
- **Parent Controller** – Client (datacenter/packet) controller requiring transport network connections to interconnect L2/L3 switches under its control
  - Also used in hierarchical controller architecture to control external vendor transport domain
- **Transport Network Orchestrator** – Orchestrates end-to-end service setup across multiple controllers

Interfaces

- **Service API** – The call interface from orchestrator to domain controllers requesting setup of transport connection of specific bandwidth and QoS profile within the controller domain
- **Topology API** – The interface between orchestrator and domain controller for exchanging network topology (actual or virtual) of the transport domain used for service/connection setup
- **Openflow Optical Extensions** – The interface between domain controller and its network elements and switches
  - Also used in hierarchical controller architecture as the interface between client/parent controller and domain controller
2016 OIF-ONF Transport SDN Interop (Planned)

- **Controller**
  - SBI: ONF OF+ OTWG extensions, Other
  - NBI: ONF T-API
    - Topology Service
    - Connectivity Service
    - Virtual Transport Nw Service
    - Notification Service
    - Path Computation Service

- **NE**
  - NBI: OF+ OTWG extensions, Other

- **Application**
  - Packet Congestion reroute
  - IMS Congestion reroute
  - NFV service orchestration
  - Others? (multi-layer restoration)
2016 OIF-ONF Transport SDN Interop
Transport SDN Benefit and Challenges

- **Benefit**: Completely automated, programmable, integrated and flexible network – leveraging the installed base in an optimized manner.

- **Technical Challenges**:
  - agree on standardized architectures and abstraction/virtualization models
  - performance of centralized systems & OF

- **Commercialization Challenges**:
  - Open Source business models
  - New business models leveraging SDN

- **Organizational Challenges**:
  - Adapt deep rooted processes across traditional silos & boundaries to leverage SDN flexibility

- **Deployment Challenges**:
  - Carrier grade SDN systems for field deployments
  - Maturity of SDN network technologies for green field deployments as well as integration of legacy networks
Thank you
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