Transport SDN Toolkit:
Framework and APIs

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Providing carriers with essential tools in the Transport SDN toolkit

- How to apply SDN to a carrier’s multi-domain, multi-layer transport network
- Transport SDN API specifications to allow deployment of SDN applications
- Prototyping and testing of real implementations for experience and interoperability
SDN Benefit and Challenges

**Benefit:**
Totally automated, programmable, integrated and flexible network - leveraging the installed base in and optimized way.

**Challenges:**

**Technical:**
- Agree on standardized architectures and abstraction/virtualization models -
- Performance of centralized systems & OF

**Commercial:**
- Open Source business models -
- New business models leveraging SDN

**Organizations:**
- Adapt processes to leverage SDN flexibility

**Availability:**
- Carrier grade SDN systems for field deployments
- Availability of new network technology in field deployments & legacy network
What is the Transport SDN Framework?

- **SDN 3 Layer Model**
  - Application,
  - Controller,
  - Infrastructure

- **How is this applied to a Carrier’s Transport Network?**
  - Multiple Layers
  - Multiple Vendors
  - Multiple Domains, e.g., Vendor or Administrative
Multi-Domain Carrier Transport SDN Framework

Infrastructure Layer - contains Network Elements
Multi-domain/multi-technology
- Geographic/Admnistrative domains (e.g., metro, core)
- Technology domains (L0/1/2)
- Vendor-specific domains

Accessed via SouthBound Interface of Controller

OIF: Optical Internetworking Forum
Multi-Domain Carrier Transport SDN Framework

Control Layer
- Carrier network will likely have multiple controllers
  - Administrative and other reasons
- May have hierarchical controllers
  - SBI-type interface from Parent to Domain controller

Infrastructure Layer
- Domain 1
  - NE
- Domain 2
  - NE
- Domain 3
  - NE

Parent Controller
- Domain Controller
  - SBI

Domain Controller
- NE
Multi-Domain Carrier Transport SDN Framework

Application Layer
- Business apps
- Network apps
- Orchestration

Isolated from Controller
- Accesses Control layer via NorthBound Interface such as REST/JSON

Infrastructure Layer
- Domain 1
- Domain 2
- Domain 3
Tested in 2014 OIF/ONF Demonstration

- 5 Carrier Labs
  - 2 Consulting Carriers
- 9 System Vendors
  - L2 and L1 Switches
  - Greenfield and Brownfield environments
    - SDN Controller and EMS
- 3 Layer SDN Framework Model
  - Infrastructure Layer with Real NEs
  - Controller Layer with multiple implementations
  - Application Layer with network orchestration
The Interfaces: Transport SDN SBI

SDN SouthBound Interface

- Open interface for Network Element switching and forwarding control
  - Logical Switch abstraction
  - Model both physical & virtual
  - E.g. OpenFlow

- Multi - Layer Support
  - L0 - Optical/WDM/OCH
  - L1 - TDM/OTN/ODU
  - L2 - Packet/Ethernet/MPLS-TP

- Utilizes Common protocol neutral Information Model
The Interfaces: Transport SDN NBI

**SDN NorthBound Interface**

- **Common interface for controlling and analyzing networks**
  - BoD services
  - Cross-domain provisioning
  - Enabling Analytics
- **Flexible interface**
  - Different levels of control
  - Potential abstraction
  - Virtual networks
- **Utilizes Common Information Model**
  - Consistency rather than divergence
General Use Cases - What are use cases driving the NBI?

- **Standards talking mainly about service creation/restoration**
  - Packet layer to steer the flows (OpenFlow as standard exists)
  - Transport layer to create services (under development ONF/OIF/IETF/etc…)

- **Operators may want to solve other problems**
  - Integration problems between vendors
  - Interworking between layers
  - Planning and equipment management
  - Optimization of the network
### Flavors of Service Creation Use Case

**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

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

**Multi-layer Network Management**
- Multilayer optimized L0-3 system with
  - Common workflows
  - Automatic routing
  - Interworking
- **Dealing with**
  - Heterogeneous technologies
  - Optimized layer usage
  - High network complexity

**Multi-vendor Support**
- Multilayer optimized L0-3 system with
  - Different control interfaces
  - Missing control IF between vendors

**Key Points**
- Matching Hypergrowth in data volume
- Extremely dynamic traffic pattern
- Addressing Time to service
- Addressing Statistical bandwidth sharing
- Addressing Dynamic data flow changes

What does the NBI access? A look at the ITU-T ASON Control Model

ITU-T ASON Model Identifies key control elements

- Call and connection control
- Routing and topology
- Resource management
- Protocols

*Figure does not imply specific distribution of components, e.g., centralized or distributed*
External APIs to ASON Control Functions

- Request service from the network
  - Service Level determines call control processing
- Control virtual network slice
  - Allocate dedicated resources for connection

* Figure does not imply specific distribution of components, e.g., centralized or distributed
APls to Access Functions: Information

Retrieve information from the network

- **Request Path Computation between endpoints**
  - Network returns path (plus alternatives, backup paths)
- **Request Topology information**
  - Invoke analytics or external path computation algorithms

* Figure does not imply specific distribution of components, e.g., centralized or distributed
SDN Controller for Transport - Functional Tool Box

- Service-request / Intent Resolver
- Connection Control
- Path Computation
- Tenant Network Virtualization
- Network Planning

Network Topology/Graph Abstraction

Southbound/Legacy Device/Protocol specific drivers/adapters

Northbound API (A/I-CPI)

Southbound API (D/I-CPI)

OIF OPTICAL INTERNETWORKING FORUM
### SDN Controller for Transport – Functional Tool Box (2)

<table>
<thead>
<tr>
<th>Southbound Protocol Driver and Device Control Interface Module</th>
<th>Multilayer Network Topology Abstraction and Virtualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Responsible for interfacing to network elements using device specific protocols (incl. Openflow)</td>
<td>• Maintains network topology database</td>
</tr>
<tr>
<td>• Could also interface with legacy management systems as well as non-SDN control systems</td>
<td>• Provides abstracted topology views to clients as per negotiated policy and contract</td>
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<td></td>
<td>• Assigns network resources to virtual abstractions</td>
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</tbody>
</table>

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<tr>
<th>Northbound API - Service/Intent Resolver</th>
<th>Multilayer Path Computation and Connection Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interfaces with client applications requesting connectivity (P2P, P2MP, MP) service</td>
<td>• Works with multi-layer (logical) network detail and logic for path computation</td>
</tr>
<tr>
<td>• Allows separation of service intent from components used to deliver the service</td>
<td>• Coordinates provisioning of the connections into the network (elements)</td>
</tr>
<tr>
<td>• Service endpoints, traffic &amp; QoS parameters</td>
<td>• Monitors the health and status of connections</td>
</tr>
<tr>
<td>• Requirements for bandwidth, availability, reliability, resiliency, diversity, etc</td>
<td>• Manages autonomous restoration</td>
</tr>
</tbody>
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Network Virtualization and Abstraction

**Network Abstraction**
- Reduce underlying complexity - simplified logical representation of resources/topology
  - Information hiding – filter/summarize details
- Management/control software systems use abstracted logical model of the network
  - e.g. ITU-T G.805 architecture
  - Subnetwork (forwarding domain/switch)
  - Link (physical, logical server trails)
  - Termination Point (logical port)
  - Subnetwork (cross) Connection (forwarding relationship in device)
  - Link Connection (monitoring & capacity assigned to a connection)

**Network Virtualization**
- Abstraction to decouple the logical view from underlying physical resources
- Involves a mapping function to dedicate real network resources to the presented virtual entities
- Allows for presenting every client with its own exclusive virtual view of same provider network
- Allows for provider to dynamically optimize and effectively manage/maintain network resources
- Subject to negotiated policy and pricing between the provider and its client
- Provides a level of flexibility to the clients to allocate and manage their “virtual resources”
Network Virtualization: Service-specific Abstraction

Type of virtual network topology exposed to client would be based on negotiated contract

- Prune irrelevant nodes/links, subject to constraints, information hiding and reduction

Based on granularity

- Client’s desired level of detail which depends on its intended application and its sophistication
- More granular topology would provide client software with more dynamic control flexibility, but at higher-end of pricing model
- e.g. dynamic VN topology-change events

Based on Service Objectives

- Presented VN topology abstraction could be a function of service objectives: e.g. optimization: lowest latency, lowest cost, highest reliability, etc
Quick Survey of Current Work

- **Transport SDN Framework**
- **Transport API Project**
- **E-NNI Specifications**
- **Optical Transport Protocol Extensions**
- **Transport API’s project**
- **Common Information Model**
- **Previous GMPLS work**
- **PCE Interface for path computation**
- **Newer work such as I2RS**

- **ASON Modeling**
- **SG 15 Architecture and Modeling**
  - Aligning with ONF SDN Architecture & Common Information Model work

- **Infrastructure Network**
- **SDN for Inter-NFVI PoP**
Next Steps: Filling the Toolbox

- **SDN Framework Whitepaper**
  - Documenting model and identifying APIs

- **Northbound Interface - OIF API Project**
  - Use ONF work aiming at commonality across platforms
    - Common Core Information Model across technologies
    - Mappable to REST/JSON interfaces
  - OIF Project to define Transport API specs
    - Use joint OIF/ONF prototyping and testing, ideally with open source participation such as ONOS, ODL

- **East/West Interface (future)**
  - Peer controllers - e.g., carrier-to-carrier
    - Work still in early stages
    - OIF E-NNI principles can be applied

- **Potential 2016 interop demonstration**
Thank You!

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Agenda

Transport SDN Drivers, Needs, Challenges
- Dave Brown, OIF VP of Marketing; Alcatel-Lucent

Global Transport SDN Prototype Demo
- Jonathan Sadler, OIF Technical Committee Vice Chair; Coriant

Transport SDN Tool Kit - SDN Framework and APIs
- John McDonough, OIF Vice President; NEC Corporation of America

Virtual Transport Network Service
- Evelyne Roch, OIF Networking and Operations Working Group Chair; Huawei Technologies Co., Ltd.

Wrap up