Outline

- SDN Definition
- Benefits
- Potential Applications
- Interfaces and Standardization
SDN = Programmatic Abstracted Network Control

- **SDN Clients**
  - Applications, Users, Orchestration Systems

- **SDN Functions**
  - Control of Forwarding and Processing of Network Traffic

- **SDN Benefit Areas**
  - Network Utilization
  - Service Development and Deployment
  - Network Operation
  - Monetization of Network Resources
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<tr>
<th><strong>SDN Benefit</strong></th>
<th><strong>Transport Network Impact</strong></th>
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| Network Utilization                       | • Application-aware optimization of resources  
• Multilayer optimization across packet and circuit                                           |
| Improved Service Development/Deployment   | • Greater separation of service development/deployment and network element embedded software  
• Virtualization of network resources                                                      |
| Simplified/Streamlined Operations         | • Streamline and integrate operations across different domains  
• Circumvent or remove restrictions of legacy operations systems                             |
| Monetization of Resources                 | • Improved charging for network resource usage and class of service                          |
Application-Aware Optimization
Use Case: DC-DC Connection

- Large, QoS-sensitive inter-DC transactions
  - e.g. VM migration, storage replication
- Time-varying $DC_X$-$DC_Y$ pairwise demand

- Fixed mesh of tunnel CIRs or circuits, sized for pairwise peaks
  - Severely under-utilized bandwidth for large windows

- Reallocate capacity where & when needed
  - Control access to ensure performance
  - 50% less capacity required for transactional traffic vs. over-provisioning

Source: L123 SDN 2012, Chris Janz, Ciena: OpenFlow–Based SDN in WAN and Carrier Networks
Network Multilayer Optimization
Use Case: Multilayer Network Management

- **Pre-SDN**
  - Separate IP and transport networks: packet flows, circuit flows
  - Managed with different tools, leveraging different skill sets

- **Post-SDN?**
  - Unified, optimization-driven control for “just flows”
  - Transport more dynamic: greater interaction with IP
  - Selective cut-thru: reconfigure and connect network ports to add bandwidth, improve performance, reduce packet transit traffic

Source: L123 SDN 2012, Chris Janz, Ciena: OpenFlow-Based SDN in WAN and Carrier Networks
OF Direct Control

Concept: Use OF controller to control each network element

- Each Network Element implements Transport OF interface and functionality
- Controller talks to each NE to provision connectivity
- Controller must be aware of detailed topology and switch technology
FlowVisor Model

- Existing OpenFlow virtualization model
- Each controller sees only a slice of the network
- FlowVisor implements policy
Emerging Service and Network Framework

Overall Application
- Many
  - Cloud computing
  - Re-optimization

Network-Specific Application
- Service setup
  - Variants (Unprotected, protected, re-routeable)
- Service maintenance
- Resource functions
Functional Decomposition & Interfaces

HL App 1
HL App 2
HL App 3

Network Application 1
Network Application 2

Controller

A
B
C
D
E

Resource Functions

Network Service Requests

Primative Requests
Resource Functions

- Controller Decomposition
- Three Categories of Interfaces
  - Defined by others
  - Defined by existing OIF specifications
  - Open for definition
Seamless Interworking

- On-demand services are provisioned, based on ASON/GMPLS control plane functions
  - Multi-domain
  - Multi-layer
  - Multi-technology

Domains can use different technologies internally.

Domains can use Network Management, SDN or distributed control plane internally.

No 1:1 relation.
SDN Architecture Issues

- How will Multi-Domain be handled?
  - What is the relationship between controllers?
- How will Multi-Layer be handled?
  - E.g., location and triggering of adaptation
  - What is the relationship to Network Management?
    - OF control vs. EMS/NMS control
- What are scenarios for SDN implementation?
  - Use cases of most interest to service providers
SDN Standards Activity

- **General:**
  - SDN/ OpenFlow Specifications
    - Open Networking Foundation
  - Appliance Virtualization
    - Network Functions Virtualization
  - Technology-specific activities
    - IETF - i2rs WG defining new SDN-oriented router interface

- **Transport network standards and interoperability**
  - ONF - Optical (New) Transport Working Group
    - OpenFlow extensions for Transport
  - OIF - optical network interoperability and testing
    - Multi-domain architecture, requirements, testing
OIF SDN Contributions

- **Carrier input for Transport SDN**
  - Use Cases and Services
  - Service Provider Requirements

- **Options for Transport SDN Deployment**
  - Multi-domain Transport SDN
  - Impacts to E-NNI and PCE functions
  - New SDN-focused Stateful PCE

- **Demonstration/testing of SDN**
  - SDN approaches using OIF testing methodology
THANK YOU!

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