Network Automation through WAN SDN control

The Role of the Network Services Platform (NSP)

- Carsten Collatz
Agenda

- **Introduction into Carrier SDN**
- SDN-based LSP Optimization
- SDN Flow Steering
- SDN Controller Northbound API Evolution
Nokia Carrier SDN
Network requirements for delivering profitable on-demand services

Service delivery
- Simple
- Automated
- Network-aware

Network optimization
- Real-time
- Centralized
- Service-aware

Operational scope
- IP & optical
- Physical & virtual
- Vendor-agnostic

How to bring together?

Profitable, on-demand network services

A new, more integrated approach required
Nokia Carrier SDN
Bridging IT and the multi-layer, multivendor network

Workflow

IT world

OSS/BSS

Services automation

Network Services Platform

Network optimization

IP and optical

Network world

Physical and virtual

Multivendor
Why NSP? Carrier SDN use cases
Service automation and network optimization

The cloud-based applications that dominate network traffic have no permanent location or duration.

Bell Labs research shows that operators are also able to support 24% more revenue-generating traffic by using sophisticated algorithms to intelligently distribute new connections across their network.
Service Controller = abstracted view of Endpoints and Policies for Applications to consume Services

- **Southbound:** Manages Complexity multi-vendor, multi-layer network mediation
- **Northbound:** Extracts Simplicity standards-based abstracted view of end-points and connectivity (ELINE, ELAN, ETREE, L3 VPN, lambda)

**Datamodel** based on Yang with information on topology, access ports, ACL, QoS type, constraints

**Open abstract APIs**
- 1. Abstracted Service Models
- 2. Service Templates / Policies
- 3. Device Specific Models

**Mediation**

**Applications**

**North Bound Interface**

**South Bound Interface**

**Protocols**

**Optical**

Programmable, multi-vendor IP/optical infrastructure (physical or virtual)

**IP/MPLS**

**Service Endpoints**

**Public**
The Promise of SDN – NSP can help to make it true

- At sports events, additional information or different camera angles can be offered on your mobile ➔ huge bandwidth will be required in a certain area for a limited time
- Data-intensive Applications such as backup can be moved at short notice from one Data Center to another for efficiency reasons ➔ the bandwidth requirements will change dramatically
- Unexpected news may create an instant spike of required bandwidth ➔ Bandwidth must be provided on demand, the network may need optimization
- Online events may spark huge interest ➔ the bandwidth can be reserved ahead of time, the network must be optimized accordingly
High Level NSP Use Cases In That Context

• Service Provisioning Acceleration
  • Simplified User Interface
  • Ability to define path constraints (especially interesting for Strategic Industry Customers)
  • Example: Abstract L2/L3 Service creation with H-QoS and Path selection for OTT SLAs

• Bandwidth on Demand
  • Be able to provide instantly resilient bandwidth for online events or as reaction to recent news events
  • Be able to provide bandwidth for customers with short-term bandwidth requirements and increase revenue
  • Example: Network Optimisation and Path Diversity policies to improve network efficiency

• Calendaring
  • Be able to reserve bandwidth for a future point in time and adapt your network accordingly
  • Support planned move of applications to another Data Center
  • Support reliably planned online events requiring significant bandwidth
  • Example: L2 Service B/W on Demand & Scheduling with dynamic QoS configuration
**NSD IP Use-Cases (Existing 5620 SAM customer)**

<table>
<thead>
<tr>
<th>Use-Case</th>
<th>Increased revenue opportunities</th>
<th>Maximise use of network assets</th>
<th>Improve customer &amp; service assurance</th>
<th>Reduce Opex</th>
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<tr>
<td>Abstract L2/L3 Service creation with H-QoS and Path selection for OTT SLAs</td>
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<td>Auto IP Tunnel Creation /Selection with path selection without pre-engineering for seamless introduction of OTT Services</td>
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<td>L2 Service B/W on Demand &amp; Scheduling with dynamic QoS configuration</td>
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<td>Abstracted NBI with Yang data models for simplified &amp; standards based OSS integration</td>
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<td>Multi-layer topology views and overlays for real-time assurance</td>
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<td>Integrated with service assurance tools to simplify assurance and improve MTTR</td>
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<td>Network Evolution with the embedded Stateful PCE for RSVP-TE LSPs &amp; Segment Routing</td>
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<tr>
<td>Network Optimisation and Path Diversity policies to improve network efficiency</td>
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## Delivering profitable on-demand services

### Service menu

<table>
<thead>
<tr>
<th>Service</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>Bandwidth</td>
<td>&lt;1GE</td>
<td>1GE – 10GE</td>
<td>&gt;10GE</td>
</tr>
<tr>
<td>Physical Port Speed</td>
<td></td>
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<tr>
<td>Physical Interface Type</td>
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<tr>
<td>Topology</td>
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<td></td>
<td></td>
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<tr>
<td>Transparent to customers routing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Transparent to L2</td>
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<tr>
<td>Guaranteed Throughput</td>
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<tr>
<td>Commit Rate and Burst Granularity</td>
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<tr>
<td>Flexible Bandwidth Granularity</td>
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<tr>
<td>Contended Service</td>
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<tr>
<td>CoS/QoS (Number)</td>
<td></td>
<td></td>
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<tr>
<td>Deterministic Routing</td>
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<tr>
<td>Working and Protect Paths</td>
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<tr>
<td>Proactive Monitoring</td>
<td></td>
<td></td>
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<tr>
<td>MEF Certified</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Options
- IP/MPLS
- Packet optical
- Optical

### Diagram

- **OSS/IT applications**
- **Services automation**
- **Network optimization**

- **SR**
- **PSS**
- **Third party**

### “I want a 1G Ethernet Service with 10-ms latency”

- Determin “best” service and tunnel to map flow
- Request new tunnel if necessary
- Compute “best” path for new tunnel
- Update topology and available tunnel bandwidth

### Auto-provision L0-L3 services using the “best” available network resources
Agenda

- Introduction into Carrier SDN
- **SDN-based LSP Optimization**
- SDN Flow Steering
- SDN Controller Northbound API Evolution
Optimizing multi-layer networks is a multi-dimensional knapsack problem requiring significant compute power.

As the network fills up, links become congested and it becomes progressively harder to fit traffic requests.

As paths are retracted, remaining link capacity becomes fragmented and leaves useful capacity stranded.

SDN/PCE can help to improve utilization:
- Efficient path computation algorithms with Bell Labs STAR (Self-Tuned Adaptive Routing), CSPF and Linear Programming.
- Periodically defragment and rebalance links to reclaim stranded bandwidth.
LSP Path Computation Algorithms
Efficiency / Load Balancing Trade off

Max Utilization on path $P_1 = 0.6$
Max Utilization on path $P_2 = 0.4$
Max Utilization on path $P_3 = 0.3$
Number of hops on $P_1 = 3$
Number of hops on $P_2 = 5$
Number of hops on $P_3 = 6$

Efficiency: Consume as little network bandwidth as possible
Balance: Avoid overloading network links to avoid deadlocks

CSPF (Min-hop)
Min-max

Min-hop: Efficient but unbalanced
Min-max: Balanced but inefficient
STAR is both efficient and balanced
Comparing CSPF and Bell Labs STAR efficiency
59 node topology after 50% of requests are served

CSPF Link Load Distribution (50% of traffic)

- Unbalanced link load distribution
- Inefficient packing, more rejected demands

STAR Link Load Distribution (50% of traffic)

- More balanced link load distribution
- Fewer rejected requests than CSPF

24% More Revenue!
Segment Routing Use-Cases: Traffic Engineering
NRC-P Constraint: Disjointness

- Use-case: two services/LSPs need to be disjoint
  - Example: PE1-PE2 and PE3-PE4 (shown)
- NSP / 7x50 behavior
  - PCEP is extended to include a ‘path-profile’ object
  - A path-profile represents a policy (i.e. a list of path parameters) that a PCEP speaker (7x50) may present to NRC-P to influence path computation
  - A Profile/template is configured in NSP corresponding to a supported path-profile indicating how NRC-P should perform the path calculation
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SDN Flow Steering
Problem Statement

• Operators want greater control over the traffic on their network to improve their ROI
  - Granular treatment of key customers/applications
  - Granular treatment of large flows
  - Virtualization/slicing of network assets
• Standardized programmable interfaces required to achieve these goals
• Target solutions must be simple for operations
  - Centralized network-wide control
  - Control decisions performed manually by Ops teams or automated based upon policy
NRC-F Use-Cases

- IP Core subnet steering: enhanced load balancing (SROS & NSP Demo mid'16)
- IP Core subnet steering: VIP customers (SROS & NSP Demo mid'16)
- MPLS Core: enhanced load balancing
- VPN Flow Steering
- DDoS Mitigation (SROS & NSP Demo 4Q'16)
- Egress Peer Engineering (SROS & NSP Demo 2H'17)

Traffic steering use-cases enabled by an SDN-enabled IP-Optical Fabric
MPLS Core: Enhanced Load Balancing
Optimize on “Top N Flows”

• Use-case explanation:
  - Targeted for “hot” PE-PE paths. E.g. DCI
  - Assurance collects link utilization stats across network, and flow stats at selected PE’s
    • P1-PE2 high utilization threshold is exceed indicating imminent congestion
  - LSP 2 is created with P1-PE2 link excluded (i.e. all busy links are excluded)
  - Redirect selected traffic to LSP 2 at PE1
  - After link utilization drops below threshold, revert back to standard traffic flow (i.e. LSP1)

• NSP/NRC-F details:
  - Identification of ‘Top N Flows’ via cflowd, and redirect to LSP2 via OpenFlow rules at PE1
  - Assurance engine performs network-wide monitoring and generates TCA for NRC-F to act on corresponding to configured KPI/thresholds
IP Core Subnet Steering: Enhanced Load Balancing
Optimize on Destination AS

- Use-case explanation:
  1. By default, egress DC-GW traffic transits via primary exit (A1/A2)
     - Native IP forwarding w/ ECMP
  2. Assurance collects link utilization stats for A1/A2 and analyze the flows based on destination AS
     - When link usage to A1/A2 exceeds a preset threshold, operator is alerted and can select a group of flows/subnets (belonging to same AS); and
     - Redirect selected traffic to B1/B2 via OpenFlow upon operator action
  3. NSP/NRC-F details:
     - Calculates subnets corresponding to destination AS
       - Correlation between BGP RIB (subnet + dest AS) and flow stats collected via cflowd/IPFix
     - Populates OpenFlow match together with redirect to indirect next-hop action
IP Core Subnet Steering: VIP Customers
Dedicated IDC Links for VIP Customers

• Use-case explanation:
  - Two sets of link groups exist: public and dedicated
    • Public link group is default exit
    • Dedicated link group is reserved for VIP customers only
  1a VIP customers sign-up for preferred treatment at DC
    • Subnets used within DC are registered and fed into NRC-F
  1b NRC-F populates OpenFlow matches (source IP subnets of VIP customers) together with redirect to indirect next-hop action
  2 Traffic originated from VIP customers is redirected onto dedicated links via OpenFlow (rather than public links)
    - Bandwidth on Demand
      • Add or remove links to dedicated link group for VIP customers
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- **SDN Controller Northbound API Evolution**
Service Provisioning Today

- Multiple integrations
- Complex APIs and provisioning systems
- Multiple layers and vendors

OSS/IT applications

Integration code

Integration code

Integration code

Integration code

Multi-vendor IP/optical network

Slow and difficult to create, turn-up and change network services
Abstract and Standards Based

With NSP

- Simple standards-based APIs
- Operator defined policies
- Automated provisioning

OSS/IT applications

Multi-vendor IP/optical network

Abstraction and automation provide simplified network service provisioning
SDN Controller / Next-Gen OSS API Evolution
Introducing the Era of Abstraction

• Next-Gen OSS / SDN Orchestrator is an emerging evolution of traditional OSS
  - Requires open ecosystem and adaptable API’s towards MV SDN controllers
  - Abstraction in order to simplify API integration with each domain SDN controller
  - Supports open ecosystem of vendors / API’s
• A true SDN controller NBI must:
  - Provide abstraction of service provisioning, hiding low-level and vendor-specific details
  - Enable rapid introduction of new service capabilities
  - Support API versioning for platform upgrade flexibility w/o breaking existing integration
Nokia investing in Open-Source for Openness

- ONOS is an open-source SDN control solution developed by ON.lab: to produce the Open Source Network Operating System that will enable service providers to build real Software Defined Networks
- Nokia has become a member of ONOS, because we believe that open-source initiatives are an important way to achieve openness and interoperability, especially in the area of SDN
- We are already a member of OpenDaylight, but ONOS is working in close collaboration with service providers on topics that we believe are very relevant for the industry
  - Solutions for managing multi-vendor optical networks
  - The CORD project (Central Office Re-imagined as a Data Center) which addresses the potential evolution of fixed access solutions and the use of virtualized solutions at the network edge
  - Intent-based networking and other forms of network abstraction
- We have committed development and test resources to ONOS an will actively collaborate with ON.lab and its member companies
- We do not intend to use ONOS to replace functionality that we have already developed for our SDN solutions NSP and Nuage. However, going forward we will leverage ONOS where and when it makes sense.
We still need single unified Fulfillment, Assurance and Optimization

Current NMS and SDN should be Complementary and Integrated
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