Why do operators need multi-layer coordination?

Víctor López

Routing Research Symposium
Network Architecture Geeks (NAG)
Towards Cloud Ready Transport Networks

Multi-layer Networks

Multi-layer restoration

Demonstrations
  • ONE project
  • O2 Germany field trial

Further steps
  • Data plane integration
  • SDN
  • Integration with Elastic Networks

Final Remarks
Towards Cloud-Ready Transport Networks
Towards Cloud-Ready Transport Networks

Multi-layer coordination

Flexible Transport Network

Photonic control plane
GMPLS + PCE

Routing, monitoring and automated IP configuration

Routing, monitoring and automated Photonic network configuration

Signalling

Cloud services

Cross-Stratum Optimization

Cloud-ready Network Approach

- The target is an E2E network able to perform automated connectivity control between end users and cloud data centers.
- This innovative network model aims to:
  - Accelerate service provisioning and performance monitoring.
  - Enable on-demand connectivity configurations (e.g., bandwidth) by end users.
  - Optimize both cloud costs and power consumption.
  - Guarantee the required QoS/QoE (…) for real time and video services.

Cloud Ready Networks rely on two main technological pillars:

- **Network Control**
- **Flexible Transport Network**

Network Control

Flexible Transport Network

Cloud Services

API

Network-Cloud interface: new services development

Resource Mngmt

IP control and resource allocation (e.g., IP v6)

IP Forwarding

E2E MPLS

E2E MPLS photon network

CPE Mobile and Fixed Access Networks

Leverage of

Elasticity & QoS

Capacity
Multi-layer networks
Independent Layers

Access Network

L2 Aggregation

Residential IP services, L3 VPN, ...

L2 VPN, ...

IP/MPLS Access

IP/MPLS Transit

IP/MPLS IX

IP/MPLS IX

IP/MPLS Transit

IP/MPLS Access

Metro

Core

ISPs Inter/ction

Core

Metro

Carrier A

Carrier B

WSON
Load balancing is triggered by the Network Management System according to off-line multilayer optimization algorithms.

Load balancing between IP/MPLS and WSON. High capacity flows (e.g., between IP access and IP interconnection) are directly transported over WSON.
Current multi-layer provisioning

CURRENT NETWORK CREATION PROCESS

1. Ask for a new IP Service
2. Check IP Network Resources Availability
3. Ask Transport Department for a Transport Layer Path
4. Check Transport Resources and Provision the Path
5. Cross Connect the Transport Path to the Right Location
6. Link Provisioned

New Link To be Provisioned

Very costly
- Time
- Money
- Human dependent

New Transport Path between A and C
New IP Path Betweenn A and C
What do we want of a multi-layer network?

- Standard interface to configure the routers.
  - NETCONF is standard (RFC 6241), but data models are vendor dependent.
  - Openflow enables standard configuration of flow tables. Is it enough?
- Interaction between the PCE and the VNTM for multi-layer networks.
  - An element is required to configure VNT to the upper layer through a standard interface.
  - Functional validation of the cooperation between Virtual Network Topology Manager (VNTM) and Path Computation Element (PCE), IPOP 2012.
Automated Multi-layer Provisioning

NETWORK CREATION PROCESS WITH OM

1. Ask for a new IP Service
2. Check Multilayer Network Resources Availability
3. Reserve Both Layer Resources
4. Link state UP
5. Link Provisioned

New Link To be Provisioned

New Transport Path between A and C
New IP Path Between A and C
Multi-layer restoration
Multi-layer Restoration

- Multi-layer restoration consist on using the increased DWDM layer connectivity and dynamicity to recover both layer failures.
- Multi-layer restoration allows to increase availability due to the higher number of resources to drive traffic available.

“The Economics of Next-Gen ROADM Networks”, Heavy Reading September 2012.
## Multilayer restoration: Alternatives comparison

<table>
<thead>
<tr>
<th></th>
<th>1+1 Protection and Multilayer Restoration</th>
<th>1+1 Protection, multilayer restoration (additional router)</th>
<th>Multilayer restoration only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPEX</strong></td>
<td>Reduction</td>
<td>Highest reduction</td>
<td>No change</td>
</tr>
<tr>
<td><strong>CAPEX</strong></td>
<td>No change</td>
<td>Increase</td>
<td>Reduction</td>
</tr>
<tr>
<td><strong>Failure recovery time</strong></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; failure: 50 ms 2&lt;sup&gt;nd&lt;/sup&gt; failure: 1 minute (approx) without FRR</td>
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</table>
FP7 STREP ONE Project
• The project has three main contributions:
  - A Network Management Adapter
  - Semantic Adaptation
  - A Programmable Management Framework

• ONE adapter enables:
  - Dynamic IP service provisioning.
  - Automatic IP Offloading.
  - Multi-layer Restoration.
Building blocks

- Execute the process orchestration inside the ONE core
- Enable interoperability between two network management layers
- Responsible of the ONE adapter configuration
- Store the orchestration and workflows for the processes

**ONE Adapter Core Modules**

- Workflow Processing
- Management Controller
- Ontology Mapper
- WorkFlow Description DB

**Modules**

- Notification Module
- Trigger Module
- Programmable Logic Modules
- AA Module
- ONE Admin Module
- Measurement Module
- Topology Module
- IP - NMS Control Module
- T- NMS Control Module
Example of ONE adapter operation – Automatic IP Link Provisioning
O2 Germany Field Trial
O2 Germany Field Trial

• Multi-layer operation is demonstrated in an O2 field trial with ONE adapter.

• Network scenario:
  § IP/MPLS equipment from Juniper (MX-240).
  § Optical transport equipment from ADVA.
  § UNI interface between Juniper and ADVA.
  § Multi-layer Manager

• The Multi-layer Manager is used for:
  § Supervise joint network configuration.
  § Automatic configuration based on network information.
  § Restoration under failure situation.
Core Networks Evolution
Telefónica I+D

O2 Germany – Data Plane Topology

Multi-layer Manager

Configuration via CLI

UNI

MX-80 R_ONE

ADVA ONE

HAMBURG

ADVA TWO

R_ONE

MX-80 R_TWO

ROSTOCK

SCHWERIN

ADVA THREE

MX-80 R_THREE
O2 Germany Field Trial - Tests

Test Summary:

- GMPLS path creation and deletion via UNI
- Automatic IP Link Provisioning
- Automatic IP Offloading
- Multi-layer Restoration
Further steps
Multi-layer target architecture

- Inefficient resource utilization
- Manual operation (IP and transport)
- Duplicated protection

- Automated operation (only at transport level)

- Improved resource utilization
- Automated operation (MPLS and transport)
- Coordinated protection

- Lack of Standardization
- Interoperability

- The target multi-layer control plane to enable automatic operation and coordinated protection is based on:
  - Hierarchical LSPs and Forwarding Adjacencies → Scalability.
  - Extended UNI interface:
    - UNI enables automatic transport connection set-up.
    - Extended UNI allows multi-layer information dissemination (TE-link, SRLGs, etc.), simplifying operation and resource utilization.
  - Multi-layer PCE → Enable scalable resource optimization and interconnection.
  - Configuration mechanisms enabling automated IP routers configuration according to the new physical topology (e.g NetConf, OpenFlow). VNTM is required for this operation.
Data Plane Integration

Separate model

Integrated model

Transceiver SR

Transceiver SR

Tx Rx

Rx Tx

Tx Rx

λ₁

λ₁

OXC

IP/MPLS

IP/MPLS Router
Line Cards

Transceiver LR

IP/MPLS
Data Plane Integration - Results

• Based on current traffic in Telefonica of Spain network, traffic is increased each year 50%.

<table>
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<tr>
<th>CAPEX reduction in the core network</th>
<th>2015</th>
<th>2018</th>
</tr>
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<tbody>
<tr>
<td>Integrated Port Cost = IP Card + Transponder – SFPs cost</td>
<td>12.4%</td>
<td>29.2%</td>
</tr>
<tr>
<td>Integrated Port Cost + 30%</td>
<td>8.4%</td>
<td>22.1%</td>
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• CAPEX savings are great but... data plane integration implies:
  - Department integration.
  - Control plane interoperability between multiple optical equipment vendors.
  - And... optical compatibility of the integrated transponders so multiple vendors can use integrated transponders.

Ongoing Work

Integrated port cost is varied since its price is not clear

Multi-layer coordination will do this

No effort in industry so far...
Software Define Networks for Multi-layer Architectures

- SDN appears as the old promise of real-time programmability of network functionalities.

Why not control a ML-network?
ONE project third year
Integration with Elastic Networks

- The elastic optical network can be configured based on:
  - Monitoring probes
  - Network status
  - Service

- Configuration can be done using:
  - Control plane
  - Management plane
Final Remarks
Final Remarks

1. Savings
   - Automated multilayer coordination enables:
     - Network resources optimization (CAPEX reduction)
     - Operation simplification (OPEX reduction)

2. ML Architecture
   - Based on a combination of standardized elements such as: extended UNI, multilayer PCE and VNTM enable multilayer interworking in multivendor networks

3. Standardization
   - Some standardization is required:
     - Extended UNI
     - VNTM
     - SDN?