SDN Testbed Experiences: Challenges and Next Steps

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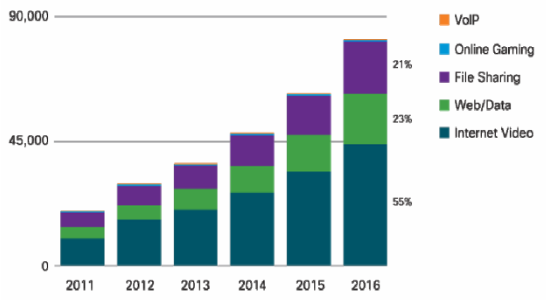
SDN Experimentation Experience
VoD Use Case Scenario

- Globally, Internet video traffic was 57% of all consumer Internet traffic in 2012 – will be 69% in 2017*
  - Growth in Video-on-Demand and Internet video to TV services

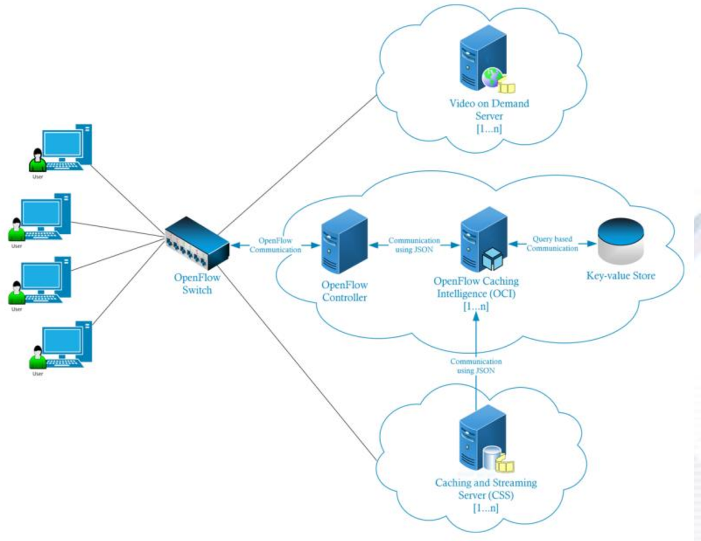


*Global consumer Internet traffic in PB/ month**

- This growth challenges the underlying infrastructure, requiring mechanisms to:
  - Reduce the number of naïve duplicate requests for identical content
  - Prevent these requests from consuming network resources

- Designed and implemented an OpenFlow-assisted VoD service that delivers content locally based on transparent caching

- Uses OpenFlow to dynamically rewrite requests and forward them to a local copy of the content :
  - Increases distribution efficiency
  - Saves network resources (improves network utilisation)
  - Improves user Quality-of-Experience



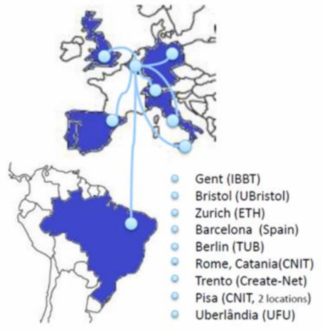
- Deployed onto a pan-European OpenFlow testbed (OFELIA)

- Demonstrated the efficiency of our service and the capability of OpenFlow to achieve the required functionality

[*] Cisco VNI Global Forecast (2012)

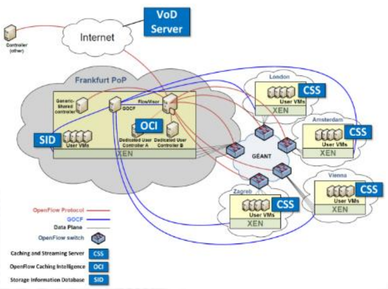
SDN Testbeds
VoD Experimentation across Europe

OFELIA
- Sep 2010 – Sep 2013 : 3 years, 17 Partners. First OpenFlow Testbed across Europe (10 federated islands). Joined on 2nd Open Call : VoD use case
- Developed a transparent, OpenFlow-assisted, in-network caching service that aims to cache video assets as close to the end-user as possible.



GÉANT
- GN3plus : Apr 2013 – Mar 2015 : 2 years, 41+ Partners. GN3Plus : Extend/expand GEANT's network across EU

FED4FIRE
- Oct 2012 – Nov 2016 : 4 years, 17+ partners
- Provide a common federation framework for Future Internet Research and Experimentation facilities.



GN3plus & FED4FIRE VoD Orchestration & Delivery Goals
- **Automated service setup and content distribution**
- **Resource control and allocation dynamically and on-demand over multi-technology testbeds**
- **Support multiple caches running across different islands with load balancing**
- **Support multiple video quality levels of the same content (using adaptive bitrate streaming – MPEG-DASH)**
- **Monitor network conditions : support caching based on network awareness (e.g. pre-cache popular content overnight)**
- **CDNi interface to allow services to interact with CDNs**

SDN Testbed Research
VoD Application Delivery

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- There is a growing need for SDN-based Service Orchestration, both for research but also industry.
- Drive SDN infrastructure from the Client (interface) and Application requirements, and respond to real-time requests and scheduled services.
  - Allowing a variety of applications for office automation, data backup and retrieval, distributed computing, and high-quality media broadcasting across SDN infrastructure.
- The SDN infrastructure does not need to be seen any longer as a composition of individual elements:
  - Applications need to be capable of interaction with the network.
  - Support of the next generation of variable and dynamic transport characteristics.
  - Automated deployment and operation of VoD services.
    - "Create a new transport connection between VoD caching sites."
    - "Respond to how many users have requested specific VoD content."
    - "Schedule these VoD services."
    - "Automatically select the peering point between CDNs based on demand/day/week."
    - "Increase link capacity after exceeding VoD bandwidth thresholds."
    - "Reoptimize my CDN network after restoration switching."

SDN Testbed Research
SDN Controller for Network Operations

- "SDN Controller" is a contentious term, it can have many different meanings:
  - Historically the term was derived from the network domain, technology and protocol mechanism.
- SDN Controller wars are ongoing:
  - Operators have an expectation of standards-based technologies for deploying and operating networks.
  - SDN controller vendors rarely provide multivendor interoperability using open standards.
  - Provisioning should be a compelling feature of SDN, however many SDN controllers use non-standardised APIs.
  - Recent Open Source initiatives are vendor led.
- Typically SDN controllers have a very limited view of topology, multi-layer and multi-domain is not supported.
- Flexibility has been notably absent from most controller architectures both in terms of southbound protocol support and northbound application requests.

SDN Testbed Research
Network Operation Framework

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- Avoiding the mistake of a single “controller” architecture.
  - As it encourages the expansion and use of specific protocols.
- Discovery of network resources and topology management.
- Network resource abstraction, and presentation.
- Routing and path computation.
- Multi-layer coordination and interworking
  - Multi-domain & multi-vendor network resources provisioning through different control mechanisms (e.g., OpenFlow, ForCES).
- Policy Control.
- OAM and performance monitoring.
- A wide variety of southbound and northbound protocol support.
- Leveraging existing technologies.
  - What is currently available?
  - Must integrate with existing and developing standards.

ABNO
A PCE-enabled Network Controller

- **Application-Based Network Operation (ABNO) framework.**
  - "A PCE-based Architecture for Application-based Network Operations"
    draft-farrkingel-pce-abno-architecture-00
- PCE provides a set of tools for deterministic path computation
  - Prior to PCE network operators might use complex planning tools to compute paths and predict network behavior
  - PCE reduces the onerous network operation process of coordinating planning, computation, signaling and placement of path-based services
- PCE has evolved:
  - Computes single and dependant LSPs in a stateless manner
  - Concurrent optimization of sets of LSPs
  - Performing P2P and P2MP path computation
  - Hierarchical PCE Architecture
  - Stateful computation and monitoring of LSPs
    - The ***state*** in "stateful" is an LSP-DB
    - Stored information about some or all LSPs in the network
  - Active PCE, resize or recomputed based on BW or network triggers
  - PCE-initiated LSP setup
    - Delegate LSP control to the PCE
    - Recommend rerouting of LSPs

SDN Testbed Research
ABNO Functional Components

- "Standardized" components and co-operation.
- Policy Management
- Network Topology
  - LSP-DB
  - TED
  - Inventory Management
- Path Computation and Traffic Engineering
  - PCE, PCC
  - Stateful & Stateless
  - Online & Offline
  - P2P, P2MP, MP2MP
- Multi-layer Coordination
  - Virtual Network Topology Manager
- Network Signaling & Programming
  - RSVP-TE
  - ForCES and OpenFlow
  - Interface to the Routing System (I2RS)

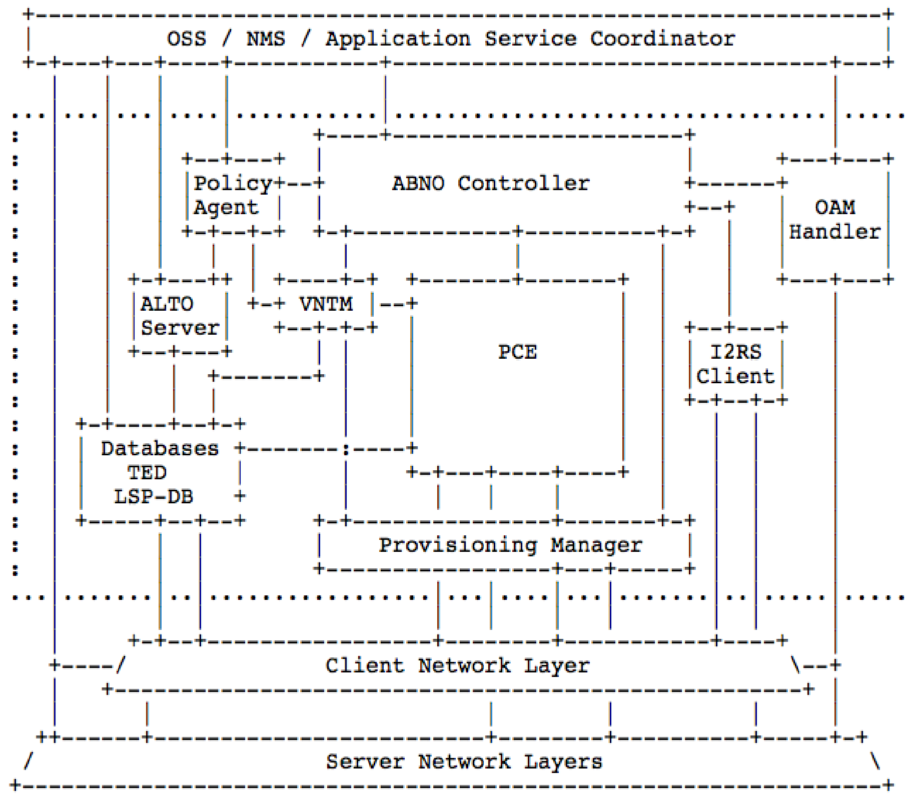
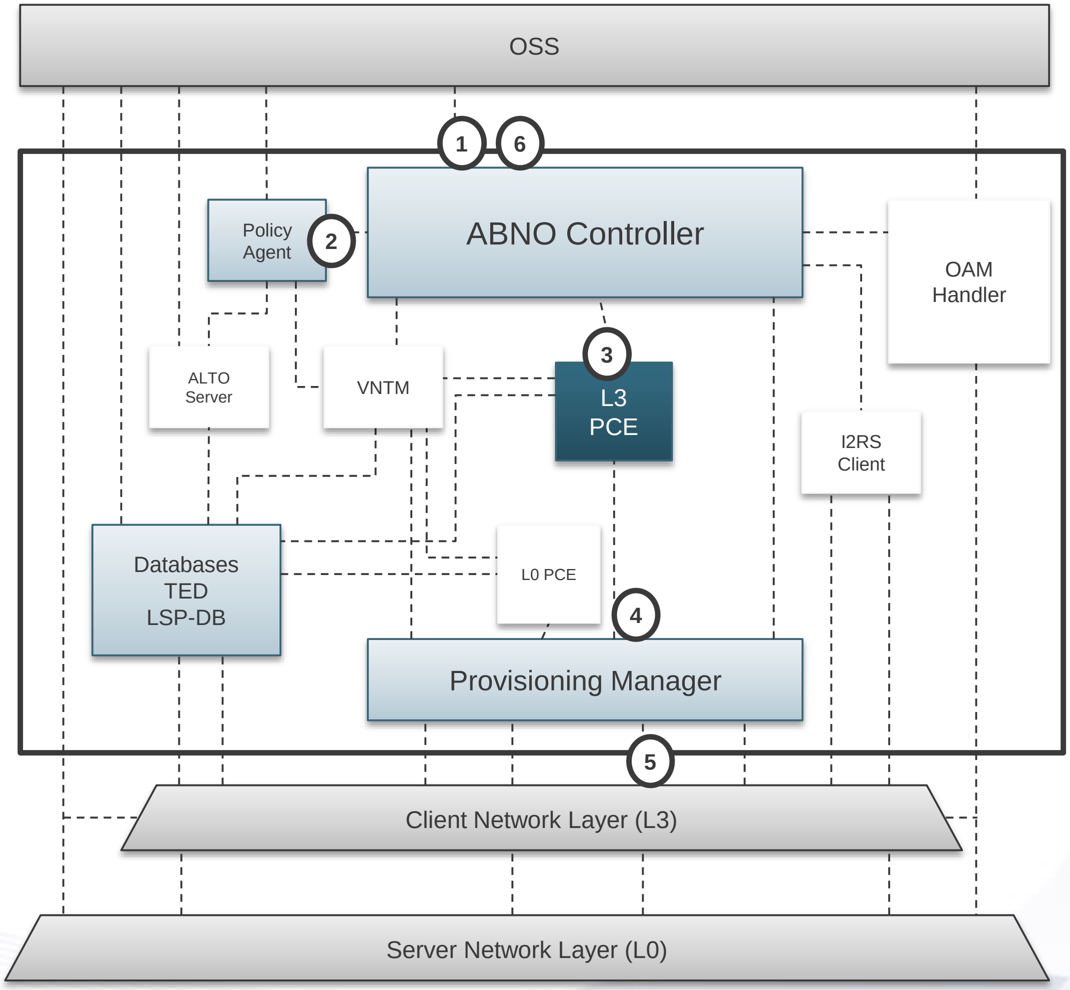


Figure 1: Generic ABNO Architecture

SDN Testbed Research
ABNO Process Simple Example



1. OSS requests for a path between two L3 nodes.
2. ABNO controller verifies OSS user rights using the Policy Manager.
3. ABNO controller requests to L3-PCE (active) for a path between both locations.
4. As L3-PCE finds a path, it configures L3 nodes using Provisioning Manager.
5. Provisioning manager configures L3 nodes using the required interface (RSVP-TE, OpenFlow, etc.).
6. OSS is notified that the connection has been set-up.

SDN Testbed Research
ABNO Use Cases

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- Current Uses Cases highlighted in the Internet-Draft

Thank you!

Questions?

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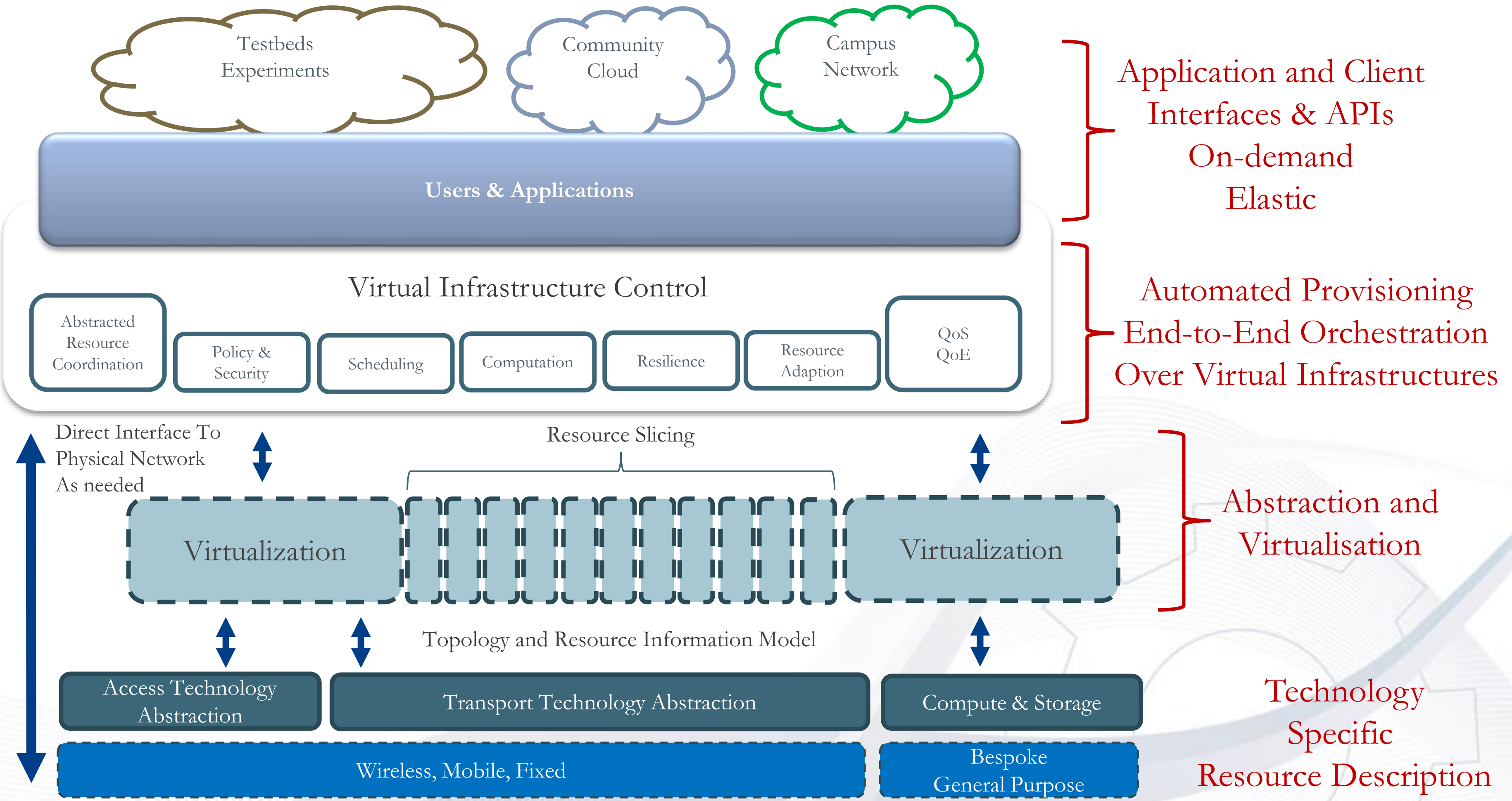
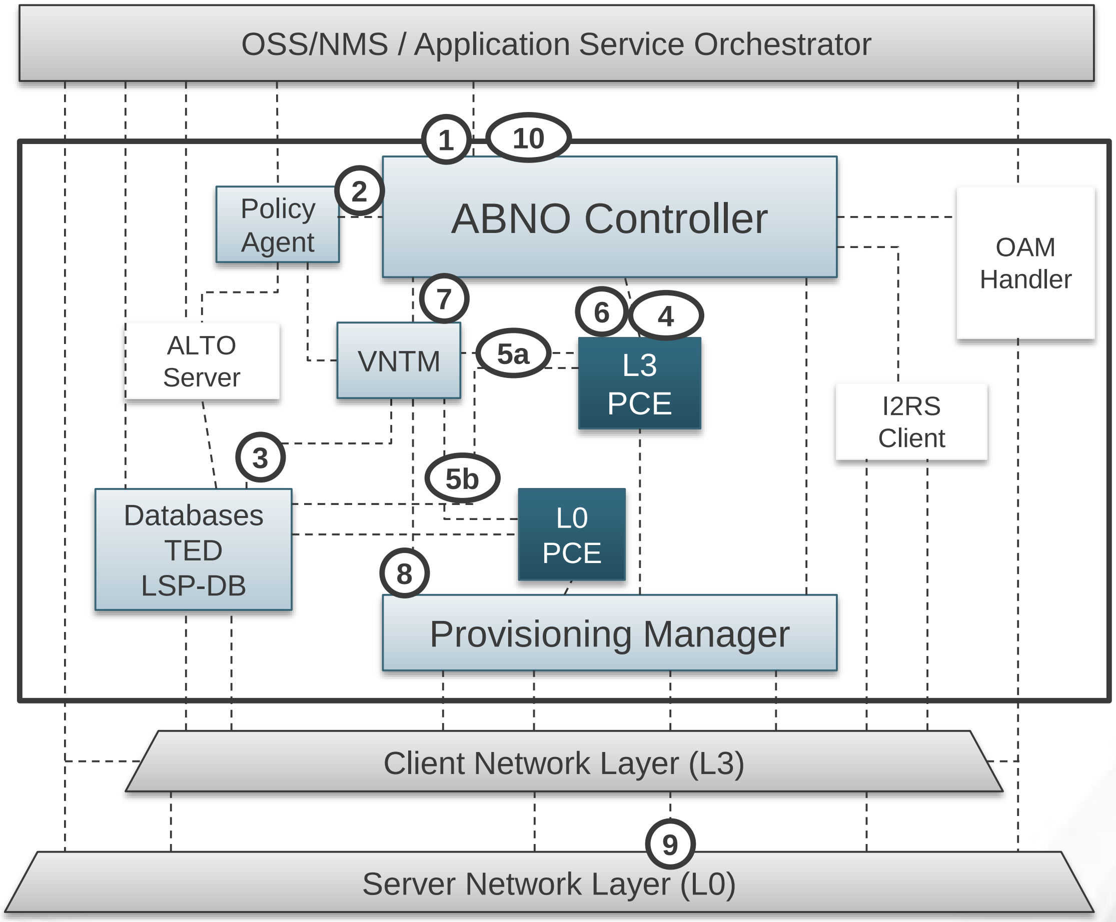
Backup Slides

- Network Abstraction & Virtualization
- ABNO Multi-layer Example

SDN Infrastructure Control
ABNO & Network Abstraction & Virtualization



SDN Testbed Research
ABNO Process Multi-layer Example



1. OSS initiates a request for multi-layer re-optimization after restoration.
2. The ABNO controller checks applicable policies and inspects LSP-DB. Obtains relationship between virtual links and forwarding adjacencies and transport paths.
3. The ABNO controller decides which L3 paths are subject to re-routing and the corresponding L0 paths.
4. The ABNO controller requests new paths to the L3 PCE, using GCO and passing the currently used resources
5. L3 PCE finds L3 paths, requesting the VNTM for Virtual Links. Virtual Links may need to be resolved via L0 PCE.
6. The responses are passed to the ABNO controller
7. The ABNO controller requests the VNTM to provision the set of paths, avoiding double booking of resources
8. The VNTM proceeds to identify the sequence of re-routing operations for minimum disruption and requests the provisioning manager to perform the corresponding re-routing.
9. Provisioning Manager sends the required GMPLS requests to the LO network nodes.
10. OSS is notified that the re-optimization is complete.