

# Next Generation Optical Network – Enabling Dynamic Bandwidth Services

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**Abstract:** Optical Transport Networks are transitioning to an intelligent Next-Generation Optical Transport Network (NG-OTN) to improve operational efficiency, deploy more cost-effective optical transport, and enable dynamic bandwidth services.

## INTRODUCTION

Optical Transport Networks are undergoing a critical transition in which the network is migrating from a static legacy SONET/SDH-based transport to a dynamic intelligent Next-Generation Optical Transport Network (NG-OTN). The driving forces behind this transition are the need to improve operational efficiency and to deploy more cost-effective optical transport than the existing ring-based infrastructure. There is growing customer demand for more bandwidth, faster provisioning, and richer sets of service functionality. In addition, there have been advances in OTN technologies and protocols that have made available a new generation of equipment that features a high degree of functional integration and is capable of supporting an embedded intelligent control plane (CP).

Advanced optical networks that include new technologies such as the Reconfigurable Optical Add-Drop Multiplexer (ROADM), wavelength selective switches (WSS), and full tunable optics are being put into service. The technology is also evolving to support migration towards IP and OTN convergence at the bearer and control plane layer. Maturity, stability and interoperability of GMPLS based control plane protocols have been shown at many industry events and individual carrier laboratories.

These advances are accomplished by the CP through distributed signaling and routing mechanisms. In most cases, the CP capabilities are embedded within NG-OTN NEs. Figure 1 below depicts a NG-OTN architecture on three functional planes. Included is the relationship between the unified CP, management plane (MP) and the transport plane (TP). The unified control plane (UCP) consists of I-NNI CPs for NG-OTN domains and control plane proxies for legacy OTN domains. The CPs and control plane proxies are interconnected by the E-NNI (External Network Node Interface) standard interfaces to form the UCP. The management plane in Figure 1 features new generation OSS components, which, to the extent possible, will be implemented according to TMF NGOSS framework architecture.

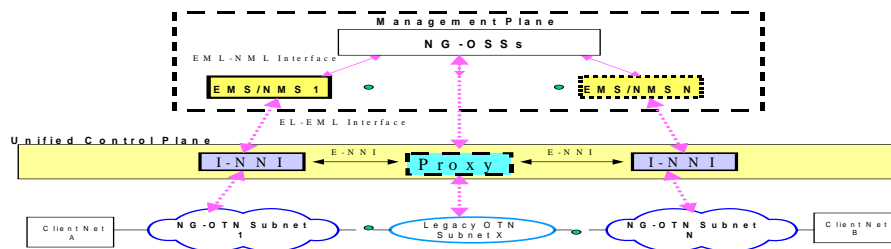


Figure 1: Next Generation Optical Transport Network Architecture

## **OPTICAL CONTROL PLANE PROMISES**

The advantages the optical control plane provides for the service provider are improved network efficiency, operational improvements and new revenue opportunities. Without these savings and potential new revenue streams, the service providers would have no reason to move away from the current mode of operation.

NG-OTN with its embedded intelligent control plane simplifies network operations by delegating several key OSS processes to the control plane for automation. Processes that are automated include discovery processes for network topology/resources/services, end-to-end lightpath routing for optimal resource utilization, flow-through service provisioning, and mesh restoration. Automation enables a self-running network and reduces OPEX by minimizing the manual and time intensive procedure in today's provisioning processes. CAPEX is improved through eliminating stranded resources through high quality inventory databases generated by the CP auto-discovery process; optimizing network-wide resource utilization by constraint-based path routing and integrated traffic engineering across network domains and achieving high bandwidth-efficiency transport by supporting mesh topology and associated protection and restoration schemes. In essence, the network becomes the database. Other network efficiencies include: ensuring flow-through interoperability across multi-vendor, multi-layer and multi-regional networks by way of standardized signaling protocols and procedures; improving network reliability and availability via the new protection and restoration schemes; CP-based protection and restoration is orders of magnitude faster than MP-based schemes - due to CP's ability to perform real-time access to network information and to react very rapidly to network events; and the dynamic, distributed routing on CP supports a variety of protection and restoration schemes to meet different customer needs.

It is envisioned that the NG-OTN Control Plane can help reduce operating costs in the long run. Operational efficiencies that can be realized include: fast service provisioning; simplification of network design - routing functions can help automate creation of network design, thus reducing manual work required to create designs in the current environment; reduce fallout rates - CP will find an optimal end-to-end path within the CP domain, thus reducing the fallout resulting from a connection performed on a segment-by-segment basis; enables integrated automated testing - as part of service activation, the CP can be used to trigger any embedded test functions to be performed; link management features can help detect mis-wiring; creation of high quality databases - (equipment and facility inventory: accurate node, link, port data; network level information: accurate network topology via neighbor discovery features; and service level information: via service discovery features); as well as increased automation in operational support.

A CP-enabled NG-OTN opens the door to new services similar to how SS7 opened up the possibilities for AIN for the PSTN. The CP holds a similar potential for a rich set of features that have not yet been defined. As carriers develop more operational experience in deploying such networks, the current static optical transport networks will become dynamic and easier to operate. Many European carriers have developed test beds to evaluate OTN CP capabilities and potentials [1]. In the U.S., carriers such as Verizon have undertaken a CP field trial to develop and establish operation processes, and develop experience to provision dynamic bandwidth services. Introduction of CP in Carrier networks seems to be following similar steps as that with the SONET deployment. Initial SONET networks were point-to-point or small-node rings before carriers developed enough operational experience to invest billions of dollars in SONET based network deployment. The evolution of NG-OTN CP is expected to follow a similar path.

## **MIGRATION TOWARDS AN ASON/GMPLS NETWORK**

The challenges which operators have to face when they decide on deploying ASON/GMPLS networks depends on a variety of factors - including the existence of a legacy SDH/SONET and DWDM transport network. If a legacy network does not exist, the operator can make the decision purely based on the benefits of ASON/GMPLS for the operator's business case. If, however, there is already an extensive transport network, the operator has two basic choices. Either to start an independent overlay network or to migrate the existing network to ASON/GMPLS as well.

While the “green field” operator has the option to start a pure ASON/GMPLS network, the established operator will most likely require some form of interworking between the new ASON/GMPLS network and the legacy transport network. It is probably this complexity that drives most operators to start with an overlay approach. In fact, many of the early adopters of ASON/GMPLS technology are operators starting the build-out of new networks.

Besides the technical aspects that have to be taken into account for the introduction of ASON/GMPLS is the administrative/operation aspect. ASON/GMPLS networks require different procedures and philosophies, planning and design rules etc. than legacy SDH/SONET networks. Hence, the operator who is planning a migration towards ASON/GMPLS needs to re-organize the operational procedures. Careful management of this process is required in order to win the operational organizations’ support for these new procedures.

### **EVOLVING TOWARDS MORE DYNAMIC NETWORKING**

In the initial phases of control plane deployment, carrier focus has naturally been upon increasing the speed of service provisioning for end-users while reaping the rewards of increased automation in the network. Some of the more challenging evolutionary aspects relate to realizing network performance and efficiency improvements that may be obtained via multi-layer optimization of switched packet and optical transport networks.

Challenges that designers and developers face include understanding the underlying networking engineering decisions that drive optical transport network reconfiguration (i.e., “where” and “when” to trigger the addition, modification, or deletion of particular optical transport layer connections), and the timescale of mid-term packet traffic pattern variations that should be considered to maintain the routing stability in the packet network. The straightforward part is the “how”, as ASON/GMPLS protocols may be utilized to effect the addition, modification, or deletion of such connections. The “where”, “which”, and “when” aspects reflect the challenging dimension of network engineering. This dimension is associated with pro-active prediction of traffic demands and ranking the most effective changes, and may be realized via a number of different methods. [2] It is also closely coupled with operator policies that govern the availability of underlying server layer resources to client layers. In particular, the decision to create/remove server layer connections is a business decision that may be represented in operator policy.

### **STANDARDS CONTEXT**

To realize a vision of multi-vendor and multi-carrier interoperable networking that supports end-to-end switched connection services on a global scale, an encompassing suite of control plane standards must be established. Standardization activities have been underway since 2000, encompassing the ITU-T, the IETF and the industry fora OIF, TMF, and (former) ATM Forum. The OIF has focused upon developing control plane implementation agreements based upon, wherever possible, available global standards and provides associated interoperability demonstrations [3] with the intent of offering an early testing vehicle for the industry.

Providing a path for graceful network evolution and implementation flexibility is ITU-T Rec. G.8080, which specifies the architecture and requirements for the ASON control plane. G.8080 provides a foundation for supporting the wide range of business and commercial relationships, organizational structures, and operational practices that may be found in real-world deployments. Further, concerted efforts over the past 7 years to marry ASON/GMPLS requirements and protocols, coupled with OIF interoperability testing, has brought the industry a long way towards ASON/GMPLS convergence.

[1] ECOC 2006, WS03, Sept. 24-29, 2006

[2] L. Cheng, J. Ellson, A. Jukan, P. Lamy, E. Varma, “Network Engineering – Control of Dynamic Link Topology in User Networks”, BLTJ, 2003

[3] “2005 OIF Worldwide Interoperability Demonstration: Dynamic Setup of Ethernet Services Over Global Optical Networks”, OIF White Paper, June 2005 <<http://www.oiforum.com/public/downloads/>