2012 OIF Worldwide Interoperability Demonstration -

Enabling High-Speed Dynamic Services

Executive Summary

The 2012 OIF Worldwide Interoperability Demonstration showcases the enabling of dynamic GbE and 10GE Ethernet services over flexible and configurable high bandwidth OTN networks. It demonstrates the use of optical control plane for end-to-end provisioning of dynamically switched Ethernet Private Line (EPL) services over enabled multi-domain intelligent optical core network, using the OIF UNI 2.0 and E-NNI 2.0 Implementation Agreements. For 2012 the focus is on control plane-enabled OTN transport technology, technology which has the capability of supporting 100Gb/sec and higher transmission rates, and which will take advantage of physical layer work being done in the OIF to drive implementation of components for 100G support.

The multi-vendor aspects of the interoperability testing give carriers confidence that different vendors and technology domains can work together. Additionally, participating vendors demonstrate mature, interoperable products based on OIF control plane specifications. The optical control plane allows carriers to open new markets for advanced, carrier-grade dynamic Ethernet services delivered efficiently through their optical networks.

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1. Introduction

Today and most likely in the foreseeable future carriers are facing the challenge to provide services over heterogeneous networks (**Figure 1**). These environments occur because of manifold non-technical reasons, e.g. company mergers, acquisitions, splits, outsourcings and the migration to next generation network technologies or operational support systems. The vision of the Optical Internetworking Forum (OIF) is that even in these difficult and complex environments seamless interworking and service provisioning is possible based on ASON/GMPLS intra- and inter-domain functions.

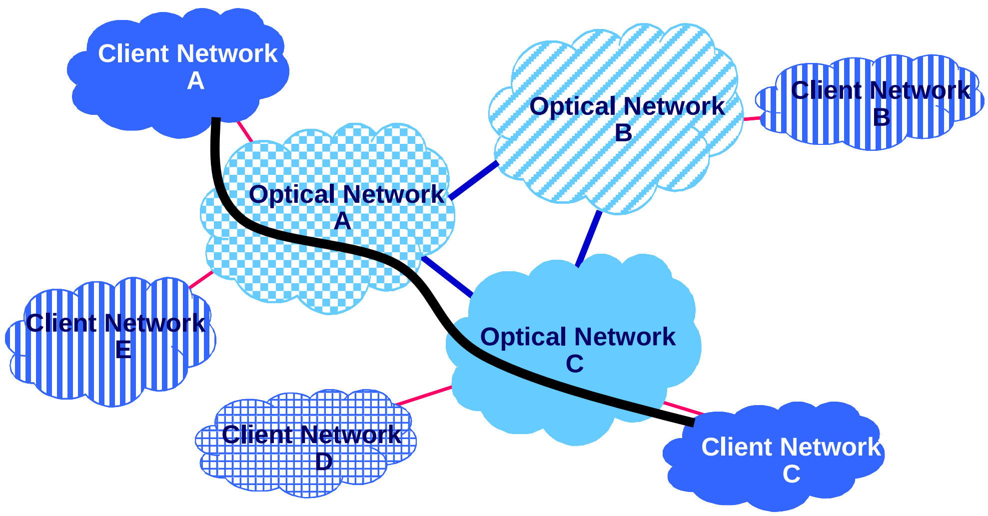

Figure 1: Typical heterogeneous carrier network environment: Multi-domain, multi-layer, multi-technology networks

OIF members understand these challenges, which require that control plane solutions be developed in the context of such heterogeneous environments, and are able to co-exist with the existing network. The OIF has long fostered cooperation among a broad and diverse group of carriers, equipment vendors, and telecom service end users in order to accelerate the deployment of advanced, interoperable, and cost-effective optical network architecture solutions. The OIF's consistent, evolutionary effort on the path towards this vision has resulted in a broad set of Implementation Agreements (IAs) that have been tested and publicly demonstrated in progressively more comprehensive environments (**Figure 2**).

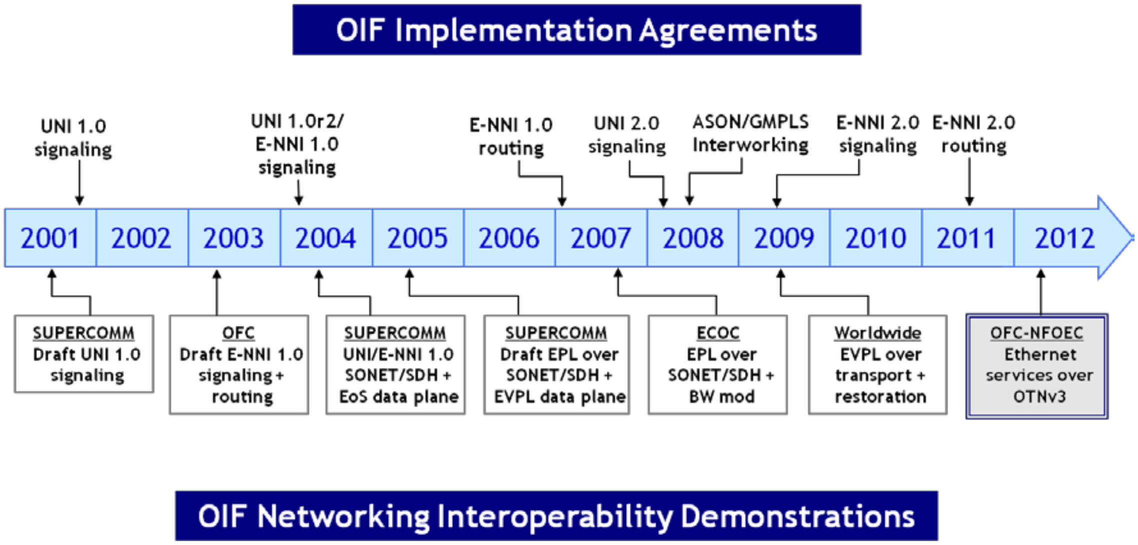

Figure 2: OIF Implementation Agreements and interoperability evaluations – validating and refining the collaborative work of the OIF (needs updating)

The 2012 OIF Worldwide Interoperability Demonstration showcases the enabling of On-Demand Ethernet Services in a multi-vendor multi-carrier environment using OTN transport technology. The OIF's 2012 worldwide interoperability test and demonstration is conducted simultaneously in Japan, France, Germany and the United States. The event highlights network-interoperable solutions among the world largest telecommunications companies, participating in the demo and employing OIF UNI 2.0 and E-NNI 2.0 Control Plane Implementation Agreements. The event demonstrates the use of the optical control plane to set up of Ethernet Private Line (EPL) services over multiple, intelligent optical core networks employing high bandwidth OTN technology.

2. Demonstration Set-Up

The OIF test network has global coverage and is based on the test facilities of four major carriers from Asia, Europe and North America, as shown in Figure 3:

- Asia: KDDI R&D Labs
- Europe: Deutsche Telekom, Orange Labs - France Telecom Group
- North America: Verizon

A number of other carriers participate in a consulting capacity, including AT&T, China Telecom, NTT and RFG Security, LLC.

In the carrier facilities, heterogeneous multi-vendor and multi-domain networks with ASON/GMPLS enabled nodes and domains were built with equipment from the following vendors:

- Alcatel-Lucent
- Ciena Corporation
- Huawei Technologies
- Marben Products
- ADVA
- EXFO
- Metaswitch
- Tellabs

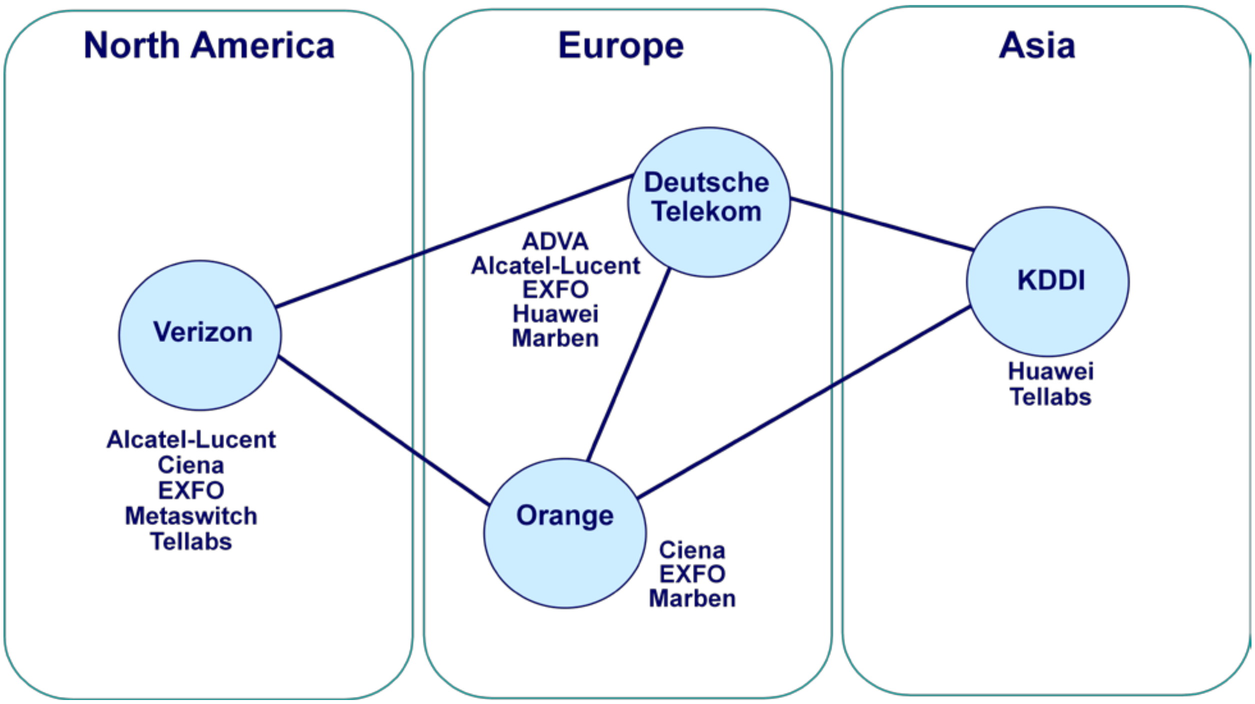

Figure 3: OIF global test network topology – carrier sites and vendor equipment distribution

The demonstration set-up in 2012 comprises the following tests:

- Data plane interoperability testing of GbE and 10GE rate Ethernet services over Next Generation (NG) OTN transport network switching equipment running at rates of 10Gbps and 40Gbps
- Data and control plane interoperability testing of on-demand EPL and OTN services using the following:
  - Applying OIF UNI 2.0 function for Ethernet client services
  - Using E-NNI 2.0 signaling and routing with extensions for dynamic OTN networking

E-NNI signaling was applied at both the Ethernet service layer and the OTN ODUj layer, resulting in a multi-layer control plane. The OIF ASON Multi-Layer control plane and data plane relationships are shown in Figure 4.

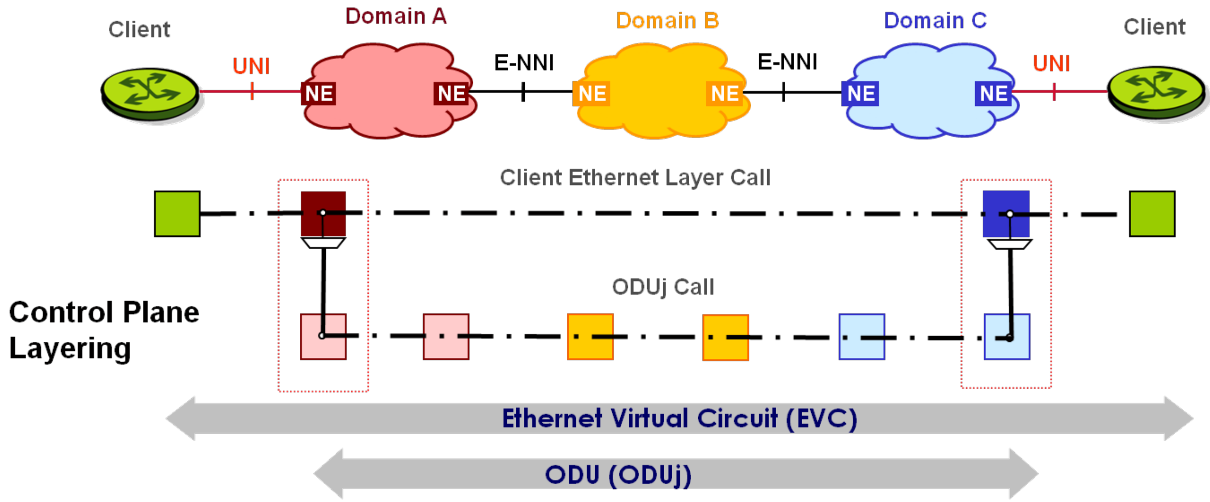

Figure 4: Multi-Layer Signaling Relationships

The carriers' labs and the local control plane enabled network domains were interconnected using OIF E-NNI and UNI interfaces resulting in a worldwide test network. This worldwide test network builds the basis for global interoperability evaluations of control plane features, supported over a multi-domain network composed of various vendors' equipment.

To support the testing, a global Signaling Communications Network (SCN) was set up over the public Internet secured by IPSec at the endpoints. In addition to the transport of signaling and routing protocols, the SCN is used for monitoring, checking and collecting information about the status of established connections and for the display of the connections crossing multiple network domains. Testing results will be presented at the OFC/NFOEC 2012 Conference in Los Angeles, USA.

One other feature of testing is the first demonstrated interoperability testing of OIF's control plane security Implementation Agreements, which are designed to protect the optical control plane from tampering or misuse.

3. Ethernet Service Types

The Metro Ethernet Forum (MEF) classifies Ethernet services (MEF 6) as E-Line (Point-to-Point) and E-LAN (Multipoint-to-Multipoint). E-Line is further divided into:

- Ethernet Private Line (EPL), defined by ITU-T Recommendation G.8011.1, where a whole Ethernet port is switched across a provider network, and
- Ethernet Virtual Private Line (EVPL), defined by ITU-T Recommendation G.8011.2, where VLAN sets can be switched to multiple destinations.

OIF UNI 2.0 Implementation Agreements (IAs) support both EPL and EVPL. A client (UNI-C) device can dynamically request the establishment of EPL or EVPL service across an operator's network. UNI signaling functions, along with the OIF E-NNI and each domain's I-NNI signaling protocol (the latter not specified by OIF), are used to establish an end-to-end connection.

The 2012 OIF Worldwide Interoperability Demonstration focuses on a reliable end-to-end Ethernet connectivity and interoperability of on-demand Ethernet Services that are defined in the EPL model in ITU-T Recommendation G.8011.2, with optional testing of data plane EVPL functionality in selected nodes.

4. OTN Transport Technologies

With the emergence of Ethernet as the predominant client signal there has been great activity within the telecommunications industry to define suitable transport technologies for reliable transport and management of Ethernet services. ITU-T SG15 had previously developed specifications for the next generation optical transport network (OTN), and with recent extensions for finer granularity GbE support and flexible bandwidth allocation, these have proved to be an ideal Layer-1 technology for handling Ethernet transport with circuit-switched, guaranteed bandwidth. OTN's "digital wrapper" structure is flexibly designed to support a variety of additional service types, including wavelength services, storage networks, video and traditional TDM, at data rates up to 100 Gbps. ITU-T Recommendation G.709 specifies a well-defined frame structure and OAM capabilities for OTN that closely follow those of already mature and widely deployed SONET/SDH technology, making it easy to grow existing carrier networks with newer OTN equipment.

OTN specifications cover a hierarchy of transport layers from the Optical Data Unit (ODU) to the Optical Channel (OCh). For the 2012 Demo, the OIF has pioneered interoperability testing of intelligent, control plane-enabled ODU switching, supporting dynamically provisioned EPL services transported over OTU transport. For the 2012 Demo, the OTN features tested include:

- Mapping of GbE and 10GE rate EPL services into OTN connections
- Switching of OTN connections for EPL across a control plane-enabled, dynamic OTN transport infrastructure using the OIF's UNI 2.0 and E-NNI 2.0 Implementation Agreements
- Integration of E-NNI control plane with OTN layer control plane using OIF's multilayer control architecture

5. Applications of Optical Control Plane

The control plane overcomes the limitations of centralized network management systems to effectively manage network resources in today's environment of increasingly dynamic, high-speed traffic. Traffic's changing patterns challenge carrier networks both in terms of traffic volume and the variable and asymmetrical nature of the traffic. This is driven by the rise in bandwidth-intensive enterprise data networking (locally, regionally and globally) and high bandwidth end user applications. As such the demand for bandwidth may move geographically and change by time of day. This fluctuation has both predictable and unpredictable components. Control plane technology makes the network more flexible to support changes in demands and it allows carriers to share core network capacity across multiple applications to reduce the amount dedicated network capacity needed to guarantee service levels thereby improving bandwidth utilization. These benefits may be attained through the various applications of optical control plane technology, such as:

- Network optimization and re-optimization via bandwidth de-fragmentation and efficient routing
- Fast provisioning based on management plane and control plane capabilities
- Dynamic bandwidth services in optical and multi-layer network environments
- Improved accuracy based on network and topology self-discovery, and self-inventory
- Reduced duplication in inventory database
- Improved service resiliency through network restoration capabilities.

6. Benefits to the Carriers and Users

6.1. Carriers' View

Within the last few years, carriers have seen increasing demand for high-speed, flexible, highly resilient transport services. In order to provide these services on an end-to-end basis across multiple network domains, while maintaining resilience and meeting customer expectation, carriers must provide interoperable technologies and networks that can support cost-effective dynamic bandwidth services in a heterogeneous network environment.

At layer 1, OTN, the emerging new transport technology provides the capability to build carrier networks of a diverse architecture, at increased bandwidth and with ever-improving operational capabilities to meet the service requirements in terms of operation, management, performance and reliability.

At the next layer, Ethernet transport supports broadband data services in an efficient and cost-effective manner, and has become an indispensable technology for carriers today. With the increased importance and popularity of Ethernet, both in carrier and client networks, carriers are now looking to provide Ethernet services with even more flexibility. Dynamic data services enabled by control plane driven Ethernet and OTN technologies open a path to meeting today's customers' requirements by introducing more efficient bandwidth granularity with suitable quality of service levels.

Control plane technologies enable the needed flexibility, reliability, and rapid service delivery in today's heterogeneous carrier network environments.

6.2. Carriers' Use of Optical Control Plane

An optical control plane is the key to realizing the full potential of transport networks to support dynamic bandwidth services. For example, the control plane supports rapid turn-up of services, efficient allocation of bandwidth in the network and reliable tracking of available resources. Standardized UNI/E-NNI interfaces provide an effective mechanism to interconnect both different vendors' equipment and different domains within a carrier's network.

The introduction of network intelligence at the optical layer improves the provisioning process, enabling carriers to define new services and bring them to the market in a timely manner as have been shown by both carrier field trials and service implementations. Furthermore, intelligent networks keep updated network information (inventory, topology) within the network itself, thus alleviating the problem of synchronizing external databases. This network concept allows devices within the network to actually manage itself and facilitate network provisioning in a matter of seconds. Initial economic analysis (qualitative and quantitative) of the impact of control plane on high-speed circuit provisioning and revenue realization indicates OSS simplification resulting in cost savings and significant opportunities for new bandwidth services with early revenue realization.

Availability of control plane-enabled recovery (protection and restoration) in multi-domain intelligent optical networks should address many intra-domain, inter-domain and end-to-end failure scenarios.

7. Related Standards Activities

The 2012 OIF Worldwide Interoperability Demonstration relies on the work of a number of standards organizations developing specifications for support of Ethernet service and next generation transport technologies, especially work of ITU-T SG 15 on OTN, and both IETF and ITU-T on optical control plane. There is a strong synergy between OIF's efforts and other standard group's activities. One of the main goals of the OIF interoperability testing is to communicate results into standards organizations where open areas or differing interpretations are found.

The OIF has worked with the MEF to understand and implement its Ethernet service definitions, including Ethernet Private Line and Ethernet Virtual Private Line services.

8. Conclusion

The 2012 OIF Worldwide Interoperability Demonstration shows end-to-end provisioning of dynamic switched GbE and 10GE rate Ethernet services over multiple, control plane-enabled intelligent optical core networks through the use of OIF Implementation Agreements for UNI 2.0 and E-NNI 2.0 Signaling and Routing. Fully dynamic control plane-enabled OTN networks and integration of Ethernet and OTN layer control are some of the new features that are the focus for 2012.

OIF interoperability testing allows the participating vendors to test their equipment's ability to support carrier requirements and desired functionality, while giving carriers confidence that different vendors and technology domains can work together using OIF Implementation Agreements, opening new markets for carriers to deliver carrier-grade Ethernet services through their optical transport networks.

9. Appendix A: List of Contributors

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10. Appendix B: About the OIF

Launched in April of 1998, the OIF unites representatives from data and optical networking disciplines, including many of the world's leading carriers, component manufacturers and system vendors. The OIF promotes the development and deployment of interoperable networking solutions and services through the creation of Implementation Agreements (IAs) for optical, interconnect, network processing and component technologies, and optical networking systems. The OIF actively supports and extends the work of standards bodies with the goal of promoting worldwide compatibility of optical internetworking products. Working relationships or formal liaisons have been established with the Ethernet Alliance, IEEE 802.3, IETF, ITU-T Study Group 13,

ITU-T Study Group 15, IPv6 Forum, MEF, ATIS OPTXS, ATIS TMOC, Rapid I/O, TMF, UXPi and the XFP MSA Group. Information on the OIF can be found at

http://www.oiforum.com.

11. Appendix C: Glossary

ASON	Automatically Switched Optical Network
E-NNI	External Network-Network Interface
EPL	Ethernet Private Line
EVPL	Ethernet Virtual Private Line
GMPLS	Generalized MultiProtocol Label Switching
IA	Implementation Agreement
IETF	Internet Engineering Task Force
I-NNI	Internal Network-Network Interface
ITU-T	International Telecommunications Union
MEF	Metro Ethernet Forum
OIF	Optical Internetworking Forum
OSS	Operations Support System
OTN	Optical Transport Network
SCN	Signaling Communications Network
SPC	Soft Permanent Connection
TDM	Time Division Multiplexing
UNI	User-Network Interface