Achieving UNI and NNI Interoperability

Executive Summary

Carriers and network service providers require cost effective dynamic provisioning systems and interoperable network solutions to deliver next generation intelligent optical networks. Control plane interoperability promises to simplify integration of different technologies and equipment as well as facilitate the introduction of new services. The OIF has adopted an evolutionary approach to the application of control plane technologies that allows the interconnection of the transport network and its clients, via the User Network Interface (OIF UNI 1.0) or different domains of the transport network, via the Network Network Interface (OIF NNI). The OIF will showcase the first transport networking solution integrating UNI 1.0 and NNI through the public interoperability demonstration at OFC 2003. After successfully completing extensive testing in the closed-door environment participated by twelve vendors, the demonstration highlights the feasibility and benefits of the OIF’s pioneering UNI and NNI implementation agreements.

This industry significant milestone achieves dynamic, end-to-end connection management between client devices and transport network elements in a multi-domain, multi-node environment. The test topology includes a wide range of network elements such as IP routers, optical cross connects, add/drop multiplexer, protocol test equipment and network software providers. The success of the interoperability demonstration among those participating vendors highlights the technical merit of the OIF’s implementation agreements, and validates that the OIF fosters an environment of cooperation where interoperability can become a reality.

Introduction

Competition and deregulation are driving carriers to create a diverse range of low cost, data-centric service options. These emerging services, which are disruptive to traditional network operational processes, can be difficult for carriers to cost effectively implement. To effectively solve this issue and maintain a manageable network carriers must:

- Create a common infrastructure to control legacy and future network elements.
- Maximize the utilization of their network resources.
- Create new automation procedures for network provisioning.
- Reduce the time, complexity and costs associated with traditional service delivery processes.

The solution to the above problems is in an abstracted plane that controls the routing, provisioning and auto-service discovery process. There are currently several processes underway that are defining architectures and specifications in this area. The Common Control and Measurement Plane (CCAMP) working group of the IETF is in the process of defining Generalized Multiprotocol Label Switching (GMPLS), a set of extensions to the MPLS suite of protocols that provide distributed signaling and routing to dynamically manage different network elements. The ITU-T Study Group 15 is defining the architecture for the Automatically Switched Optical Network (ASON). ASON describes the components of an optical control plane and their interactions. Interactions across a multi-vendor divide are required to have the representation of standardized protocols.

To efficiently deploy this technology, carriers must have a wide selection of clearly defined, stable and interoperable implementations. The OIF has actively taken the role of defining a set of deployable implementation agreements that satisfy the Carrier Requirements specified by the OIF Carrier working group. These implementation agreements are based on profiles of the GMPLS protocols, with appropriate extensions to satisfy the additional requirements. This work has resulted in two efforts. UNI defines the GMPLS profile and extensions that are used at the boundary between the clients and the transport network.
NNI defines the profile and extensions used among different vendor domains within a single service provider network.

**History**

Founded in 1998, OIF is an open forum focused on accelerating the deployment of optical internetworks with over 250 member companies. The organization aims to provide a venue for equipment manufacturers, users, carriers and service providers to work together to resolve deployment issues and develop key specifications to ensure the interoperability of optical networks.

![Figure 1: OIF Technical Working Groups](image)

There are currently six OIF working groups:

- **Architecture Working Group**
  Based on these requirements from service providers, the Architecture Working defines the concept, definition, analysis, and documentation of matters pertaining to the architectures for optical networks.
- **Carrier Working Group**
  Defines and generate guidelines for the services and functions to be supported by the future optical networking products.
- **Interoperability Working Group**
  Based on OIF implementation agreements, and methods, the interoperability working group facilitates OIF testing methodologies to validate conformance and contribute technical leadership for interoperability trials.
- **OAM&P Working Group**
  Develop operations, administration, maintenance and provisioning requirements and guidelines that may apply to planning, engineering and provisioning of network resources.
- **Physical & Link Layer Working Group**
  Specifies on functions and characteristics necessary to define and establish the interconnection of signals between Optical Internetworking equipment.
- **Signaling Working Group**
  Specifies implementation agreements related to signaling protocols to be used between optical network elements, reusing existing standards when applicable.
In 2001, the OIF hosted the industry’s first true multi-vendor, multi-technology, interoperability demonstration of the Optical User-Network Interface (UNI) at SuperComm. A subset of the UNI implementation agreement that includes connection control was selected for the demonstration. Twenty-five (25) vendors successfully demonstrated interoperability across a mesh of different devices.

To accelerate the deployment of optical networking technology and facilitate industry convergence on Interoperability OIF is hosting a second round of testing focused on UNI and Routed NNI interworking.

**OFC UNI/NNI Interoperability Demonstration**

The demonstration at OFC during March 25 – March 27, 2003 brings together twelve (12) equipment manufacturers and software vendors to hold the world’s first routed optical networking interoperability demonstration event. The participating vendors include Alcatel, Avici Systems, Ciena Corporation, Data Connection Limited (DCL), Elematics, Mahi Networks, NEC, Motorola/Netplane, Nortel Networks, Sycamore, Tellabs and Tellium. The demonstration follows ten days of extensive multi-vendor “hot stage” testing activity conducted at the University of New Hampshire Interoperability Lab between March 7th and March 17th, 2003.

The primary objective of the event is to demonstrate provisioning across an intra-carrier, multi-vendor network. Figure 2 shows an example topology, which consists of multiple transport domains and the attached client equipment. Each domain can be implemented using one or more network elements. Connection requests are initiated either over a UNI signaling [OIF UNI 1.0] interface or through a management agent. Mechanisms and protocols enable topology discovery and provisioning.

![Figure 2: Sample demonstration Topology](image-url)
Interoperability testing featured UNI and NNI protocol implementations. An example topology consisting of actual control plane (CP) and simulated data plane is shown in Figure 3.

Figure 3: Control Plane and Data Plane Coexistence

Transport equipment vendors implement their node abstraction in two ways.
- Abstract node: In this model, a domain is represented by a single node that serves all inter-domain links.
- Border nodes and abstract links: In this model, the routing controller serves border nodes within the domain.

Technical highlights of the demo:
- Soft Permanent Connection (SPC) and UNI client initiated connections
- Hierarchical link state routing with optical constraints
- Variety of domain architecture model

Test Methodology

A comprehensive test plan outlined strict requirements and default parameters for device configuration. Testing issues found in earlier test events were minimized by documenting configuration options and restricting behaviors. Testing focused on three areas:

- Multi-area traffic engineering to OSPF-TE
- UNI initiated RSVP-TE signaling extensions interworking with OSPF-TE
- SPC initiated RSVP-TE signaling extensions interworking with OSPF-TE

The first rounds of testing consisted of point-to-point domain functionality. Figures 4 and 5 demonstrate the topologies used for multi-area traffic engineering extension to OSPF-TE and connection formation.
Once interoperability was achieved with pairs of domains, larger groups of three and four domains were setup and tested. The pairings were rotated so that each vendor received the maximal exposure. Formal rotations were run on strict intervals and any interoperability issues were carefully documented and retested at later scheduled slots if the testing was incomplete. Testing was allowed to progress according to schedule and code fixes were implemented to minimize waiting time.

Once the formal rotations verified a superior level of interoperability, larger groups of domains were connected together. Eventually 2 large networks were constructed and connected into the demonstration topology. Connection formation was thoroughly tested.

**Conclusion**

The Optical Internetworking Forum (OIF) OFC 2003 event successfully demonstrates an interoperable UNI/NNI solution that supports flexible service creation in a multi-vendor network environment. This demonstration confirms that carriers of all types can utilize UNI/NNI specifications to implement dynamic provisioning across networks consisting of elements from multiple equipment suppliers. Importantly, the simplified, automated UNI/NNI service creation can contribute to significant capital and operational savings for carriers. Cooperative efforts such as those showcased at OFC 2003 highlight that UNI/NNI can be utilized by carriers to offer new services over their existing networks in a cost-effective manner.

UNI/NNI network solutions are increasingly relevant and important as competition and deregulation drive carriers to create a diverse range of low cost, data-centric service options. Supporting these services requires an abstracted management plane that is in control of optical routing and signaling. While optical routing and signaling can promote dynamic service creation, proprietary single-source solutions create high equipment costs for service providers.
Glossary

EMS  Element Management System
LMP  Link Management Protocol
NMS  Network Management System
NNI  Node to Network Interface
OSPF Open Shortest Path First
RSVP Resource Reservation Protocol
SPC  Soft Permanent Connection
UNI  User to Network Interface

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