SUPERCOMM 2001 OIF UNI Demonstration White Paper

Executive Summary

The development of the Optical UNI Specification comes at a time of exciting developments in the telecommunications and optical networking industries. The pace of technological change and innovation, encouraged by the growth in network communications, have created an environment in which vendors and service providers are working collectively to define the direction of the industry and to lay the groundwork for the next evolution in optical networking.

This Optical UNI development effort was driven by the need to provide a more streamlined approach to service turn-up and management. The traditional multi-layer network topology is challenged to provide substantial operational and technological benefits to the ever-evolving data-centric networks of the future. With the evolution from the multi-layered network to a more streamlined network topology, both vendors and service providers need to react appropriately to the market shift and provide both technological and operational support within their respective organizations. The OIF, driven by the collective efforts of its many members, has begun laying the roadwork for increased interoperability through the demonstration of the first phase of the Optical UNI 1.0 specification as seen at SUPERCOMM.

This specification provides the first truly open, coordinated effort to define signaling, neighbor and service discovery and addressing for optical networking devices. The specification is anticipated to provide the necessary foundation for the vehicles of dynamic service creation and provisioning. More importantly the optical interoperability standards movement allows the industry to coordinate and realize the true value of recent technical innovations in the industry, increasing the size of the industry as a whole for all participants.

I. Industry Background

The Voice to Data Evolution

In this new millennium, the need for additional bandwidth to carry data traffic has increased exponentially – shifting from the voice centric networks we were familiar with for many years. End-customers are demanding more bandwidth to carry the most valuable commodity in this new age, information, as seen by the surge in demand for access technologies such as cable modems, xDSL, and wireless data. Eventually, data will be 99 percent of the content sent over telecommunications networks (Source: Ryan, Hankin, and Kent). Although there is still a need for voice traffic, technology now

exists to migrate this traffic over IP based networks, and yet still provide an acceptable quality of service for that traffic.
Another trend emerging in the telecommunications industry is the shift from a multi-layered network to a streamlined approach to network provisioning and management. In the recent past, IP traffic would traverse over ATM networks, which would traverse within SONET/SDH networks, and then over the DWDM backbone, as seen in **Figure 1**. Although this type of network topology was functional, the time that it took to turn up services over those networks could potentially approach 4 to 6 weeks. These extensive service-provisioning times were mainly due to the lengthy provisioning times required for turning up SONET/SDH networks. Network operators had to provision the ADMs and cross connects throughout the end-to-end circuit, which across multi-technology, multi-vendor environments was an extremely manual process.

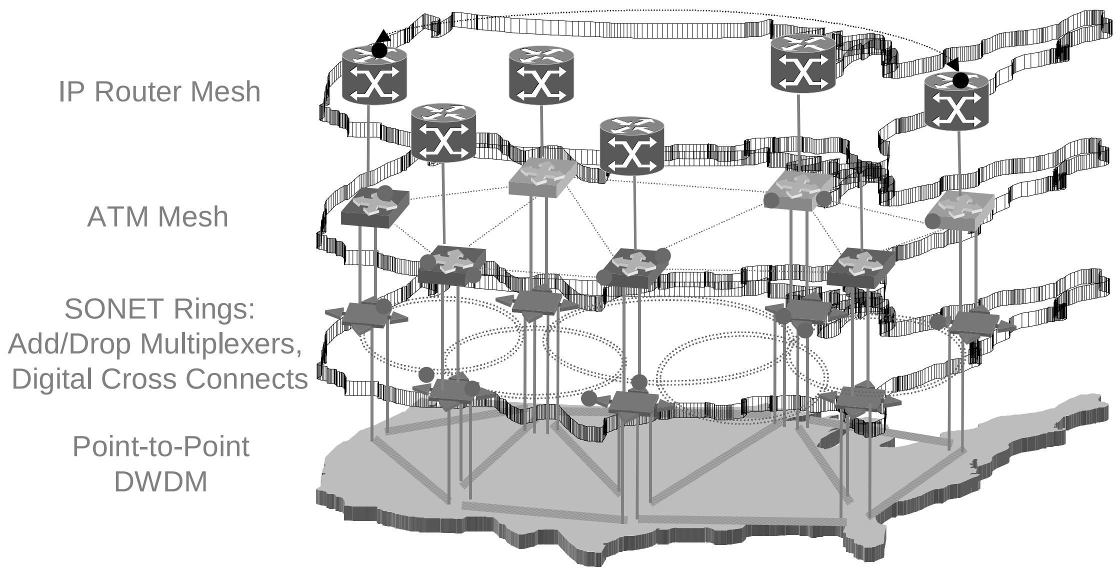

Figure 1 – Today's Core Network

Additionally, as bandwidth needs increased, new hardware would have to be "swapped out" from the network, which would initiate the installation process again. Another challenge that many end-users and service providers realized was that the multi-layer network was not as flexible as they would prefer. In a traditional SONET/SDH network implementation, service offerings were limited to specific discrete bandwidth pipes such as OC-3, OC-12, and OC-48, due to the equipment hardware constraints. Unfortunately though, customers often needed a fraction of the bandwidth allocations (10Mbps Ethernet, etc.), and as a result, service providers could not efficiently and economically provision their existing bandwidth resources to meet those customer demands.

As a result of these business drivers, telecommunications networks are undergoing a transition from a multilevel network topology to a more streamlined network topology.

Future networks will streamline the intermediate layers of the current architecture such that minimal layers remain. **Figure 2** depicts two basic layers: (1) the upper IP layer which packages and labels the data, and (2) the optical transport layer that carries the IP traffic over the core of the network.

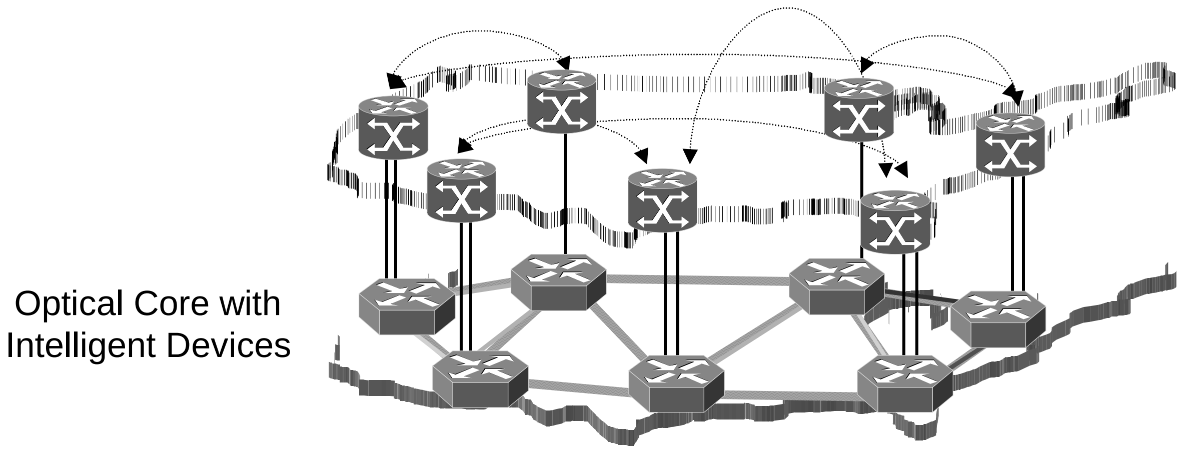

Figure 2 – Next Generation Core Network

II. Market Environment

The optical telecommunications marketplace today presents many challenges to service providers and the vendors that supply equipment to those service providers. The opportunity exists to supply the growing demand for data services to institutions and residential end-customers, but the economics of the industry have been challenged by a number of factors driving the development of Interoperability standards.

Growth of Data

As outlined earlier, the growth of data-centric communications and services is straining the voice networks and challenging service providers to re-architect networks and services. As quality of service surrounding packet-based technologies improves, these technologies will become the standard for network communication of most, if not all services. This convergence of networking technologies towards a streamlined approach (as discussed in the Introduction) will result in voice services becoming just another data service.

Decline of Traditional Business Models

Related to the fundamental growth in data-centric networks, is the declining value of traditional business models in the telecommunications industry. Margins in long-distance voice have declined over recent years, approaching the point of break-even. Competition in corporate data services has increased, and the proliferation of last-mile solutions such as DSL and Cable has eroded small and medium business revenue. Furthermore, customer expectations of decreasing broadband access prices have, and will continue to force carriers to respond and maintain their position as a viable competitor. This phenomenon is forcing service providers to re-evaluate their fundamental business models and the underlying technologies that enable those business models to protect revenues and maintain lowest-cost operations. In particular, new business models must utilize the following:

- Scalable network architectures and the efficient allocation of network resources
- Dynamic provisioning of bandwidth and services
- Reduction in the marginal cost of servicing additional subscribers
- Increased revenue through innovative pricing models

Increasing Competitive Pressures
The business opportunity in telecommunications has not gone unnoticed, as seen by the continual establishment of small CLECs and ISPs throughout the country. The equity and debt markets, together with industry deregulation, have lowered many of the barriers to entry into the telecommunications industry. While recent economic pressures have challenged this growth, the industry will continue to realize increased competition due to the anticipated growth in subscriber demand.

Changing Equipment Supply Chain
Lastly, the new industry environment has also created enormous investment and technological innovation in the equipment, software and services that comprise the core telecommunications infrastructure. More vendors are supplying an increasingly diverse marketplace with differentiated solutions to the challenges outlined above, each with the potential of disrupting the technical evolution of optical networking. Increasing numbers of vendors and solutions places additional pressure on the industry to solve interoperability issues, and develop consensus on the foundations of technical innovation with standards.

Market Enablers
At the core of next generation networks, is a number of enabling technologies that have contributed to the network topology evolution. At the physical layer, key advances in tunable optics, faster optoelectronics and network processors, larger, more intelligent switches, and more versatile optical fiber have allowed systems vendors to build additional functionality into network devices. At the services layer, advances in routing, service-aware switching, Quality of Service, and security management, as well as the software tools for designing, managing, provisioning and billing the network have all contributed to the realization of the next-generation network.

Fundamentally, the intelligent hardware and software enabled by these technologies must deliver a network of networks that:

- Adapts to topological changes (architectural and the addition / deletion of network elements)
- Facilitates service velocity through a common control plane

- Scales according to the needs of the network and its associated services
- Accommodates various service level specifications and type of protection

Of high priority, is the establishment of optical interoperability specifications such as those outlined in Optical UNI 1.0. Such specifications provide a solid foundation for the development of next-generation equipment and solutions for service providers to deliver new services under new, more dynamic business models.

III. Key Aspects of an Optical UNI

From an optical network standpoint, the following are the three key parameters that must be optimized to provide the benefits of an IP/optical layered network:

- Bandwidth Efficiency
- Rapid Provisioning
- Quality of Service

Bandwidth Efficiency

A key optical parameter that must be realized is the requirement for bandwidth efficiency. As mentioned previously, many of the legacy networks were equipped with the technology to provide a static bandwidth allocation at service turn-up. As bandwidth needs change in today's competitive service environment, carriers must be able to dynamically re-assign bandwidth resources as new bandwidth requests enter the network. Without dynamic reallocation capabilities, those service providers will potentially forfeit business to other more flexible providers.

Rapid Provisioning

Another key component that must be optimized within an optical network is the provisioning time. Traditional networks consisted of a variety of disparate network management systems that each needed to be provisioned as separate entities, both from the data environment and the optical/telecom environment. As a result, provisioning times were extremely long, as many of these systems were not able to interoperate and therefore minimize manual intervention, especially across multi-technology and multi-vendor environments. With the evolution of the Optical UNI 1.0, data platform vendors and core optical platform vendors will have standard interfaces promoting interoperability in provisioning and management criteria. This will enable carriers to set up and tear down connections dynamically across multi-technology and multi-vendor network applications. The OIF Optical UNI 1.0 hopes to provide that enabling technology and usher in a new era of optical network services.

Quality of Service

As the market shift continues from voice-centric to data-centric networks, carriers must still provide Quality of Service criteria associated with those voice networks. This criterion includes service availability and reliability, service restoration, and survivability associated with SONET based networks. As mentioned above, although the demand for voice transmission has not dissipated, the demand for those voice-based networks has decreased significantly. Obviously, the demand for voice services will not dissolve, but the enabling technology for those services will shift to a data-centric network infrastructure. Voice traffic will traverse data networks through encapsulation in IP packets (VoIP), but must still satisfy Quality of Service parameters dictated by legacy networks for voice applications today.

IV. Optical UNI Demonstration Introduction

Demonstration Description

At the SUPERCOMM tradeshow in Atlanta, the OIF will sponsor an optical UNI interoperability testing demonstration. Approximately twenty-five companies will be participating in the demonstration. The purpose of the demonstration is for each of the vendor companies to showcase their adherence to the signaling aspects of the Optical UNI 1.0 specifications.

Demonstration Components

The Optical UNI demonstration will consist of a finite number of functional components that all vendor companies must adhere to, to qualify for showcasing in the demonstration at SUPERCOMM. The following is a list of those components:

- *IP Control Channel Configuration* – For the SUPERCOMM Interim UNI the mandatory realization of the IP Control Channel is out-of-band, out-of-fiber over an Ethernet. Other configurations (in-band, in-fiber, or out-of-band, in-fiber) are optional.
- *Manually Configured Neighbor Discovery Information* – Neighbor Discovery allows two connected network elements to discover port connectivity information. For the SUPERCOMM Interim UNI, the information will be manually configured.
- *UNI Signaling* – The mandatory signaling protocol for the SUPERCOMM Interim UNI is based on the RSVP-TE protocol, CR-LDP based signaling is optional.
- *UNI Transport Connection at OC48/STM-16 Rate* – The demonstration must include support for OC48 or STM-16, concatenated or non-concatenated transports. Other interfaces will be considered optional for this demonstration.

IP Control Channel Configuration

For the demonstration, the mandatory IP control channel (IPCC) transport mechanism for the demonstration is out-of-band, out-of-fiber. A 10BaseT or 100BaseT Ethernet Network will connect both UNI-C agents and UNI-N agents involved in a single round of experiments.

The signaling messages that are exchanged over the network are RSVP messages encapsulated in IP over Ethernet frames. Additionally, this assumes that the whole demonstration network is a single bridged network. The clients (e.g. routers) and ONE’s (optical network element, e.g. switches) should be directly connected to a single IP subnet via a switched Ethernet LAN, no routers shall be in the path of signaling messages.

Manually Configured Neighbor Discovery Information

The second main component of the SUPERCOMM demonstration is the neighbor discovery functionality. To understand the neighbor discovery capability, one must first understand the different elements of an optical UNI interface. As seen in **Figure 2** below, the UNI-C is the client and the UNI-N is the network/server element. The ONA is the Optical Network Address for clients attached to the optical network. The UNI-C IPCC and UNI-N IPCC are unique IPv4 addresses that are used as the source and destination addresses of UNI signaling messages. Within the SUPERCOMM demo, IPCC addresses will be routable IPv4 addresses assigned at the interoperability event. The UNI connection endpoints are identified by ONA addresses, as seen in black. Each ONA is an IPv4 address assigned to one or more physical transport links connecting a UNI-N and UNI-C. For the purposes of the SUPERCOMM demo, ONA addresses will be unique IPv4 addresses assigned prior to the interoperability event.

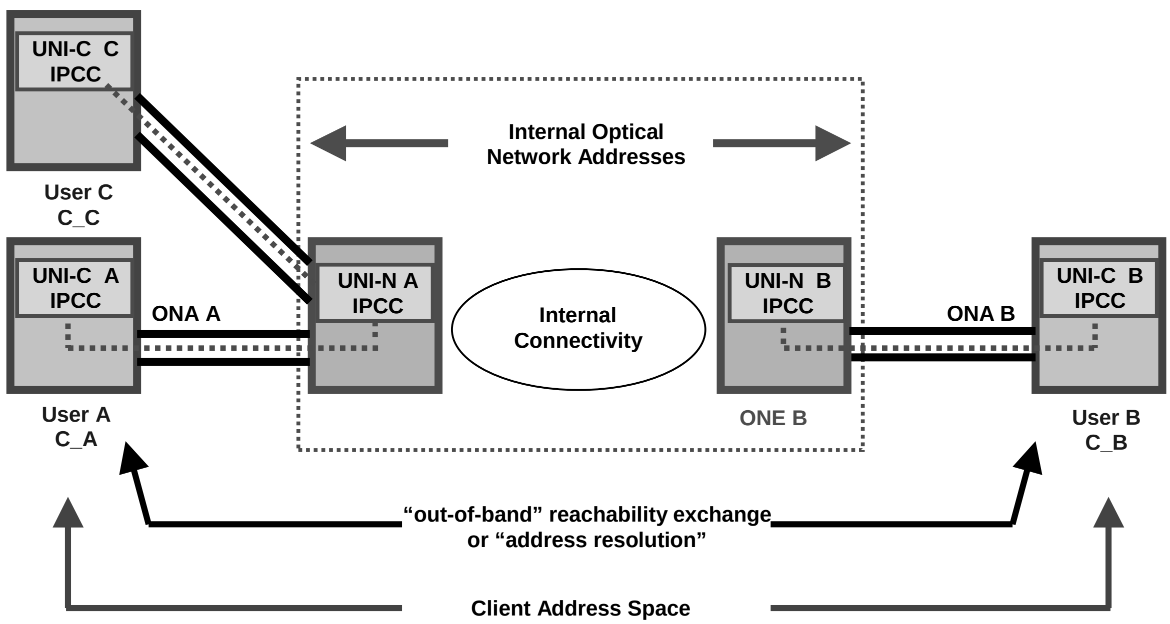

Figure 2 – Optical UNI Network Configuration

As seen in Figure 3 below, the UNI-C and UNI-N devices will be interconnected through physical ports, which are identified by their port identifiers (CP_x and NP_x). The configured neighbor discovery table in each device will contain the mapping between local and remote port identifiers.

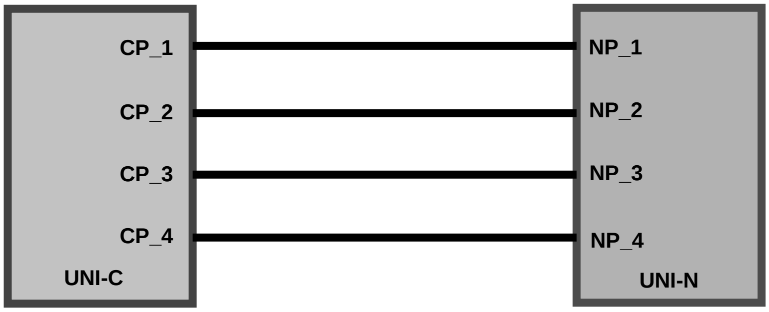

Figure 3 – UNI-C to UNI-N Port Mappings

<u>UNI Signaling</u>
For the SUPERCOMM interop demo, the following signaling test scenarios must be supported by each of the vendors:

- Successful connection establishment
- Connection tear-down initiated by source UNI-C
- Connection tear-down initiated by destination UNI-C

Other test scenarios that may be shown but are not required include the following:

- Connection tear-down initiated by the Network
- Connections setup rejected by the Network due to unknown ONA address
- Connection setup rejected by destination UNI-C. This could be due to the destination UNI-C not accepting connections from the UNI-C originating the request, for example source UNI-C may belong to different administrative domain.

<u>Demonstration Implementation</u>
During this section, the three key component functions for the SUPERCOMM demo will be discussed below.

Successful Connection Establishment
As seen in **Figure 4** below, a signaling will need to take place between the Source UNI-C and the Destination UNI-C.

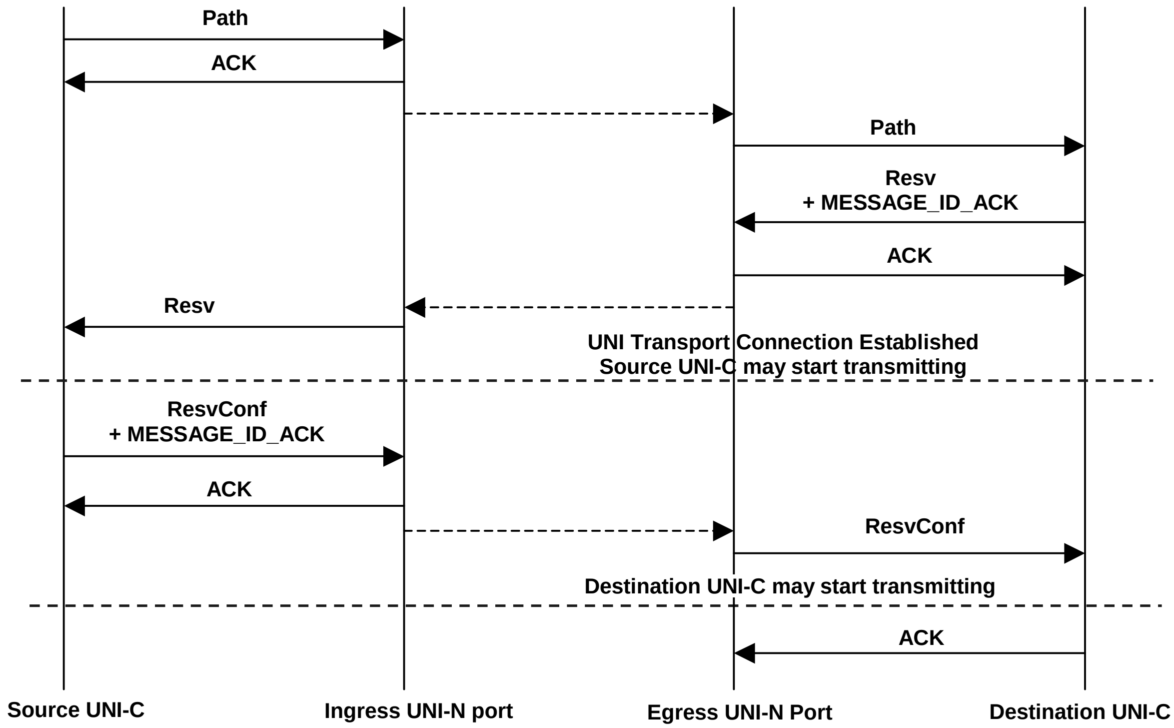

Figure 4 – Successful Connection Establishment

It is assumed that the optical network element (UNI-N) has established the optical connection across the optical network element (ONE) before sending the Resv message to the source UNI-C. Within this implementation, the source UNI-C must not start data transmission before the Resv message is received. The destination should not start transmission before the ResvConf message is received.

Connection Tear-Down Initiated by Source UNI-C

As seen in **Figure 5** below, the source UNI-C will initiate the teardown of the connection. During this teardown process, the source UNI-C should not terminate the data channel before the PathTear message is received at the destination UNI-C. Otherwise, the destination UNI-C network element might generate various alarms.

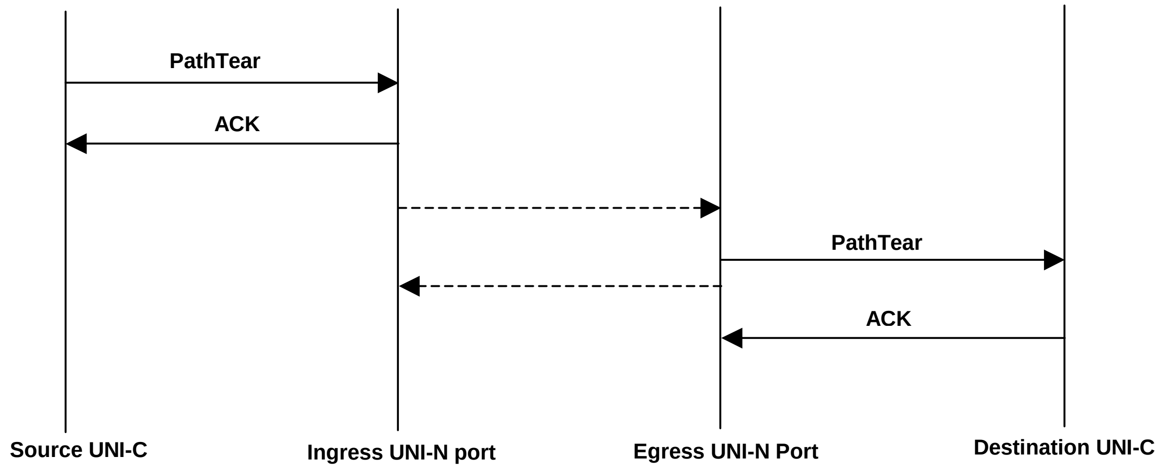

Figure 5 – Connection TearDown Initiated By Source UNI-C

Connection Tear-Down Initiated By Destination UNI-C
As seen in **Figure 6** below, the destination UNI-C will be initiating a connection tear down. The tear down is initiated by the ResvTear message, which is sent by the destination UNI-C. See the sequence of signaling that takes place between the source and destination UNI-Cs below.

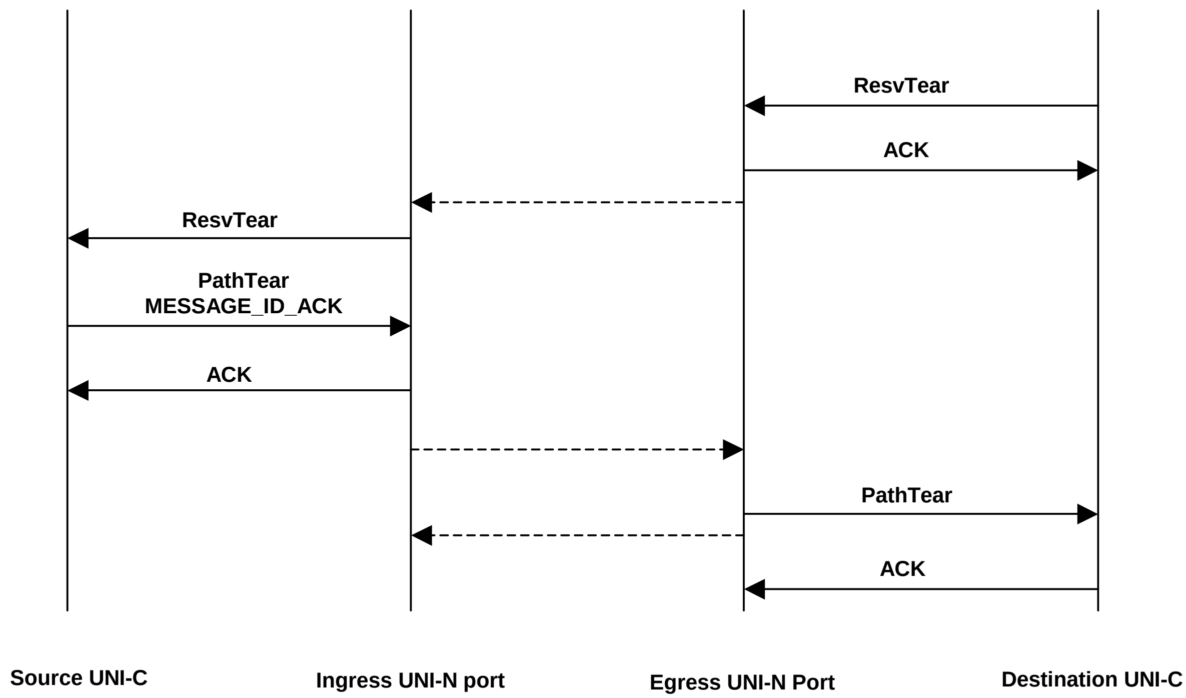

Figure 6 – Connection Tear-Down Initiated By Destination UNI-C

Other Implementation Options
The Optical UNI implementation being shown at the SUPERCOMM demo will showcase a subset of the Optical UNI 1.0 specification. This demonstration signifies the start on the road to interoperability between IP and optical networks. This specification

focuses on the establishment of high-speed bandwidth on demand between IP and optically based networks.

The OIF Optical UNI Interoperability Demonstration does cover the setup of connections between IP and optical networks, but the specification details capabilities beyond the scope of the demonstration. Prior to the development of complex carrier-focused applications, certain functionality must be completed and integrated into the Optical UNI 1.0 specification including:

- Addressing/Signaling
- Neighbor discovery
- Service discovery

The list above provides a superset of the types of capabilities to be demonstrated at the SUPERCOMM trade show. As with most technical specification development, the creation of the specification will undergo an iterative, evolutionary process. The initial step within the Optical UNI specification development is the addressing/signaling component. This component will be shown at the OIF Optical UNI demonstration at SUPERCOMM.

V. Optical UNI Advantages

The OIF Optical UNI 1.0 specification and the public demonstration of the specification is the first step towards an open, non-proprietary standard for interoperability between a client (UNI-C) and optical network element (UNI-N). The OIF Optical UNI 1.0 provides the foundation for building the road to interoperability between client and core nodes in the optical network. In turn, the Optical UNI 1.0 functionality provides the foundation for quick and easy provisioning of end-to-end services, and creates a vehicle for advanced application development. Even so, the core strength of the Optical UNI specification is dependent upon the support provided by major equipment vendors and service providers.

Service Provider Benefits

For service providers, the benefits of the Optical UNI will exist at many levels. First, an open interoperability standard will provide the catalyst for stable, reliable network infrastructure, regardless of the equipment origin. Network operators will realize increased network design, implementation, and management flexibility. Through dynamic topological and service discovery, edge devices can be added to the network and automatically configured for available services allowing carriers to explore new physical-layer and service-layer network architectures. This will allow rapid, dynamic provisioning and service creation at lower average and marginal cost.

For a carrier's carrier, interoperability standards will allow the setup of dynamic marketplaces for trading available bandwidth. An open interoperability standard will also increase flexibility in purchasing allowing 'best of breed' equipment to be mixed and matched according to carrier requirements. Furthermore, the investment in infrastructure is also protected from changes in vendors or equipment mix. Ultimately these advantages will allow service providers to differentiate services, easily tailor services to demand and develop flexible pricing strategies.

End-Customer Benefits

Many of the benefits of the Optical UNI realized by the service providers are also passed onto the end-customers, i.e. corporate enterprises, institutions, residential customers and other service providers. The dynamic, efficient provisioning of bandwidth and services allowed by intelligent UNI-enabled network devices translate to bandwidth, QoS and service demands being met in real time. Customers only pay for the bandwidth they need or use and can signal in "real time" if their demand changes. Because of this enabling, flexible technology, end-users are more willing to purchase these services. As a result, service providers are able to reach customers that may not have been reached with legacy service offerings. For carriers and corporate customers, efficient bandwidth markets allow services to be upgraded or changed, while for many customers the promise of outsourcing their communications needs through managed services.

Vendor Benefits

By participating in the development of the Optical UNI specification, equipment vendors contribute heavily to increasing the overall size of the market opportunity for optical networking. As service providers begin to see the benefits of optical internetworking, the demand for next generation systems and services will increase. The UNI specification provides a catalyst for the widespread adoption of these systems as the industry realizes the value of recent innovation in optical networking.

For the vendors of networking equipment, the Optical UNI provides a vehicle for developing innovative services and applications based on differentiated product platforms. With a robust interoperability standard, equipment vendors are able to focus on rapid product innovation without interoperability concerns or reliance on 'all-or-nothing' network build-out wins. The risks associated with product development of leading-edge systems decrease if they are interoperable with more common equipment. From the carriers' standpoint, the risks associated with new products also decrease.

Additionally, through participating in the Optical UNI demonstration, the vendor is clearly displaying commitment to inter-operating with next generation networks. From a market perception standpoint, the service providers will react positively and support that vendor. As a result, the vendor could realize additional revenues that may not have been realized otherwise.

VI. Conclusion

In conclusion, the Optical UNI demonstration at SUPERCOMM signifies a monumental step down the road to complete interoperability between the data/IP and optical networks. As with any evolutionary technological change though, the most successful changes result from a methodical multi-phased process. The UNI 1.0 specification, and the first public demonstration of the specification at SUPERCOMM 2001, represents a positive step towards the vision of unified standards in optical networking equipment internetworking. A total of [25] vendors of networking equipment and software have come together to further this goal and define a common direction for network interoperability. Without this common understanding and support from the networking community, the vision of a commercially viable Optical UNI would not be as clear as it is today.

Another vital component required for interoperability success is the full support of the vendors, service providers, and end-customers to follow through with the standards development and support. These three key groups must not only contribute to the interoperability movement through engineering efforts, but also embrace the changes through process and implementation modifications. The OIF hopes to function as the catalyst that integrates those market-segments and allows them to both develop and adhere to those specifications.

The first phase of the Optical UNI that defines the establishment of communications amongst a diverse roster of available optical networking equipment will be demonstrated publicly at SUPERCOMM in Atlanta. This first step will lay a solid foundation for further development in out-of-band and in-band signaling, automatic neighbor and service discovery and dynamic bandwidth provisioning. With continued backing from the industry at all levels, the OIF believes the road to interoperability begins with the Optical UNI 1.0 demonstration.

VI. Acronyms

UNI – User Network Interface
OIF – Optical Internetworking Forum
ATM – Asynchronous Transfer Mode
DWDM – Dense Wave Division Multiplexing
QoS – Quality of Service
UNI-C – User Network Interface Client side
UNI-N – User Network Interface Network side
DSL – Digital Subscriber Loop
UNI-C IPCC - User Network Interface Client side Internet Protocol Control Channel
UNI-N IPCC - User Network Interface Network side Internet Protocol Control Channel
ONA – Optical Network Address

VII. Sources

User Network Interface (UNI) 1.0 Signaling Specification, OIF Contribution OIF2000.125.3, December 2000

Interim User Network Interface (UNI) Signaling Implementation Agreement for SUPERCOMM 2001, OIF Contribution OIF2001.152.4, May 2001