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Working Group: **Architecture & Signaling Working Groups**

Title: **Proposal to form a Project on Architectures and Signaling for Configurable All-Optical Networks**

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Source:

Adel A. M. Saleh (Editor)
Jane M. Simmons
Lotfi Benmohamed
Corvis

Yassi Moghaddam
Avici Systems

Jonathan Lang
Calient Networks

Angela Chiu
Robert W. Tkach
Celion Networks

Raj Jain
Nayna Networks

Rauf Izmailov
Yoshiharu Maeno
Yoshihiko Suemura
NEC

Subra Ambati
Joe Parker
Opthos

Brian Brown
Richard Lauder
Malin Premaratne
Redfern Broadband Networks

ABSTRACT: Long-reach optics and configurable all-optical networks provide economic benefits for carriers in terms of both capital and operating expenses by significantly reducing the amount of equipment required in the network. Such networks are currently entering the marketplace, and there is a desire in the OIF and other standards organizations to generalize their respective architectural models to include all-optical networks. This contribution is a proposal for initiating a new project in the OIF to address the specific features of all-optical networks as they relate to signaling for automatic provisioning and restoration of optical paths. Since an all-optical network naturally forms a domain, another important aspect of this project relates to the more general problem of establishing connections across multi-domain networks.

For additional information contact:
The Optical Internetworking Forum, 39355 California Street,
Suite 307, Fremont, CA 94538
510-608-5990 phone ✦ info@oiforum.com

1. Project Summary

1.1. Working Group Project

Signaling specifications for configurable all-optical networks.

1.2. Working Group(s)

Architecture and Signaling.

1.3. Problem Statement

Automatic provisioning in networks where O-E-O crossconnects are connected by point-to-point WDM links is currently being addressed by the UNI 1.0. Configurable all-optical networks, however, have specific properties (e.g., routing schemes intimately tied to the underlying technology) that are not adequately captured by the UNI 1.0 model. In order to achieve end-to-end signaling through both O-E-O and all-optical networks, these properties need to be addressed by developing appropriate signaling specifications. Since an all-optical network naturally forms a single domain, the more general problem of establishing connections across multi-domain networks also needs to be addressed.

1.4. Scope

The scope of this project is to identify the required interfaces and develop the signaling specification for supporting and maximizing the benefits of configurable all-optical networking within a single-domain or multi-domain context.

1.5. Expected Outcome

An implementable signaling specification that accommodates the specific properties of configurable all-optical networks.

1.6. Schedule

To be determined.

1.7. Merits to the OIF

This signaling specification will be within the scope of the OIF mission and will allow for interoperable implementations of signaling for automatic provisioning and restoration of optical paths across both O-E-O and all-optical networks.

2. All-Optical Networks

2.1. Motivation

Long-reach optics and all-optical networks provide significant cost savings by eliminating much of the required equipment in a network. In addition to capital savings, the reduction in O-E-O transponders and electronic switching equipment also results in more rapid provisioning of services. Furthermore, all-optical networks more naturally provide useful optical services like *multicasting* and switching at *waveband* granularities.

The ease of provisioning in all-optical networks makes them advantageous for the deployment of dynamic wavelength services. As all-optical networks enter the marketplace, it is highly desirable that a signaling specification be developed for automated provisioning and restoration in such networks.

2.2. Properties of All-Optical Networks

One of the key characteristics of an all-optical network is the distance a signal can travel without the need for regeneration, i.e., the optical reach. The optical reach in a given network is dependent on many impairments, such as accumulated noise, chromatic dispersion, polarization mode dispersion, nonlinear effects, and cross-talk, as well as on the type of amplifier design. Also, in inverse-muxing applications, which are well suited for all-optical networks, the choice of wavelengths needs to take into account degradation variations among wavelengths. All of these considerations will, of course, be very dependent on a particular vendor's implementation. Functions such as routing, selection of regeneration sites, and selection of wavelengths are necessarily intricately tied to these properties of the network.

One of the goals of the project proposed here is to determine how best to interface to all-optical networks. It will be necessary to explore issues such as: is it practical to deploy multi-vendor all-optical networks; is it possible to sufficiently capture the technological properties of an all-optical network to allow higher layers to peer with it. Earlier OIF proposals have already begun to address these issues, as summarized below.

2.3. All-Optical User-to-Network Interface

Contribution OIF2000.278 proposed extending the UNI specification to include an All-Optical-UNI (AO-UNI) for interfacing to an all-optical network.[2] The AO-UNI would reside at the interface between the O-E-O layer and the all-optical network "cloud", as depicted in Figure 1. The basic premise of the AO-UNI is that it is too difficult to codify the wide array of properties of an optical network and that features such as routing and regeneration within the all-optical network should remain within the control of the all-optical domain. Thus, the O-E-O layer and the all-optical layer would operate in a client-server (or overlay) model. (A variant of this model is the augmented model where the all-optical layer also passes reachability information to the O-E-O layer.[3])

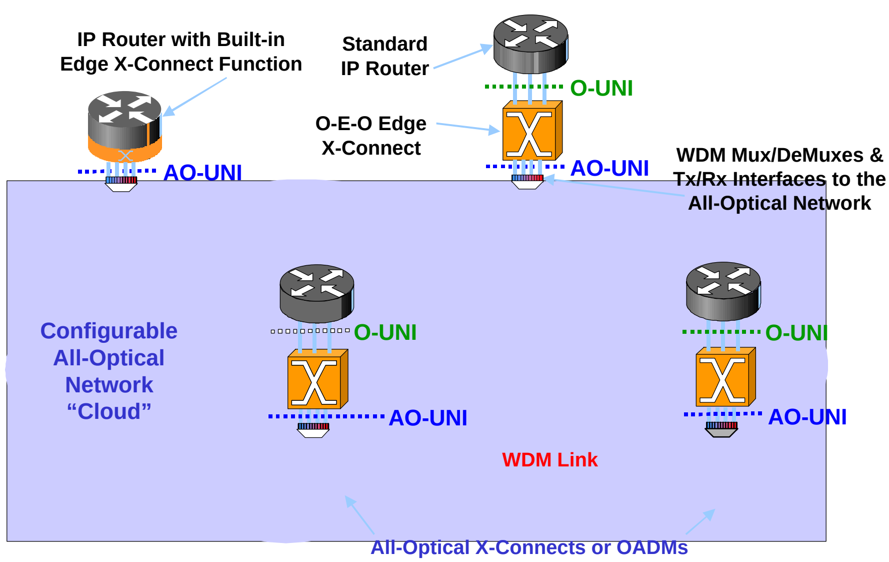

Figure 1. REFERENCE MODEL 1: *The Optical-User Network Interface (O-UNI) operates between the IP Router layer and the O-E-O Crossconnect layer, whereas the All-Optical UNI (AO-UNI) operates between the O-E-O layer and the All-Optical cloud. While the O-UNI can support a peer-to-peer model or client-server model, the recommended mode in Contribution OIF2000.278 for the AO-UNI is client-server.*

2.4. Standardizing Routing within the All-Optical Layer

Contribution OIF2000.254 addresses the scenario where the transmission equipment within the all-optical network is provided by one vendor, and the all-optical crossconnect is possibly provided by another vendor, as shown in Figure 2.[4] An Optical Link Interface (OLI) was proposed that would reside between the all-optical crossconnect and the DWDM transmission system. The OLI would be used to communicate performance monitoring information and line system characteristics, including some of the optical link characteristics described earlier. This would enable interworking between the multiple vendors of the all-optical network, which would lead to more efficient utilization of network resources and more rapid restoration.

One challenge will be how to capture all of the appropriate line system characteristics that will enable routing and selection of regeneration sites within such a network model. Contribution OIF2000.251 proposed how to capture some of the linear and nonlinear impairments within this all-optical network model.[5] For example, it was proposed in [5] that the control plane support the following options: (1) Allow proprietary routing within the all-optical network cloud, adding regeneration when needed (as also proposed in [2]). (2) Enforce homogeneity within the transparent domain by imposing constraints on system design and network engineering. (3) Attempt to standardize the routing protocol within the all-optical layer, at least for limited applications.

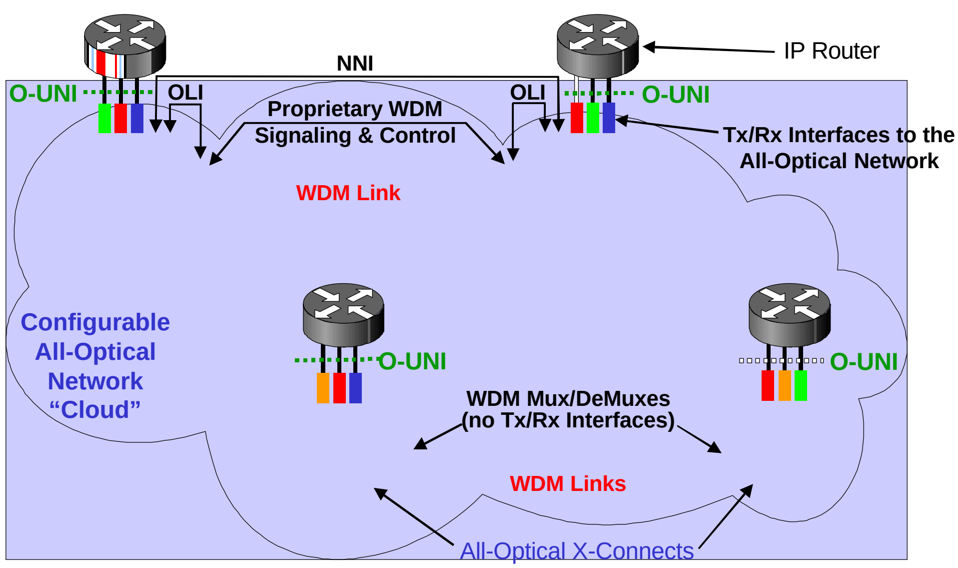

Figure 2. *REFERENCE MODEL 2: In this model, which is proposed in Contribution OIF2000.254, emphasis is on signaling and routing within the all-optical network. An Optical Link Interface (OLI) is proposed to communicate performance monitoring information and WDM link system characteristics to the all-optical cross-connect layer. The use of such information to enable routing within the all-optical cloud was proposed in Contribution OIF2000.251.*

2.5. Granularity Considerations

As mentioned earlier, all-optical networks are naturally capable of switching at granularities coarser than a wavelength, e.g., waveband or fiber switching. Thus, it is likely that all-optical networks will be comprised of multiple granularities. Part of this project will examine the interfaces between the different wavelength granularity layers within the all-optical network. For example, would a wavelength layer and a waveband layer operate in a peer-to-peer arrangement or in a client-server mode.

2.6. Multi-Domain Considerations

It is important to support provisioning and restoration across multiple domains, which could include both core and metro regions. Since an all-optical network naturally forms a domain, an important part of this project is to consider multi-domain architectural and signaling issues.

3. Conclusion

All-optical networks offer numerous benefits to carriers. It is important that standards be developed to adequately address the special properties of such networks. There are clearly many issues that need to be resolved in how best to interface with all-optical networks. We feel that these issues are important enough to the OIF community to warrant the authorization of a new project to adequately address them.

4. References

[1] B. Rajagopalan (Editor) et al., “User Network Interface (UNI) 1.0 Signaling Specification,” OIF2000.125.3, December 2000.

[2] A. Saleh et al., “Proposed Extensions to the UNI for Interfacing to a Configurable All-Optical Network”, OIF2000.278, November 2000.

[3] OIF Carrier Group, “Carrier Optical Services Framework and Associated Requirements,” OIF2000.155.1, September 2000.

Interworking between Photonic (Optical) Switches and Transmission Systems over Optical Link for UNI Interface (OLI) using Extensions to LMP”, OIF2000.254, November 2000.

[5] A. Chiu et. al., “Wavelength Routing in All-Optical Networks,” OIF2000.251, November 2000.