Technical Brief

Sycamore Networks Implementation of the ITU-T G.ASON Control Plane

Abstract

This document provides a detailed overview of the control plane behavior of Sycamore Networks SN 16000 Intelligent Optical Switch in an International Telecommunications Union-Telecommunications (ITU-T) G.8080/Y.1304 Automatic Switched Optical Network (ASON) compliant Optical Transport Network (OTN).

Introduction

The ITU-T is responsible for creating recommendations to promote global standards for telecommunications (1). As part of its broad charter, the ITU-T has drafted a series of recommendations, the G-series, pertaining to Transmission Systems and Media, Digital Systems and Networks (2).

G-series recommendations include ITU-T G.8080/Y1304, frequently referred to as G.ASON, or simply ASON (3). ASON describes the control plane components that are used to provide fast and reliable connection set-up, maintenance, and tear down within the OTN, in response to both signaled and management driven requests.

The ASON control plane is divided into domains that match the administrative, geographic, or vendor domains within the OTN; and the transport plane resources used by the ASON control plane are also partitioned to match these domains. ASON defines logical reference points between domains where signaling and/or routing information is exchanged. The reference point between an administrative domain and an end user is the User to Network Interface (UNI). The reference point between domains is the Exterior Network Node Interface (E-NNI). The reference point within a domain is the Intra Network Node Interface (I-NNI).

The use of domains and logical reference points separates control plane communications and creates an Overlay Model (Figure 1). In an Overlay Model, only limited information is shared across domains; and the complete optical topology and resources within a single domain is not exposed outside of the domain.

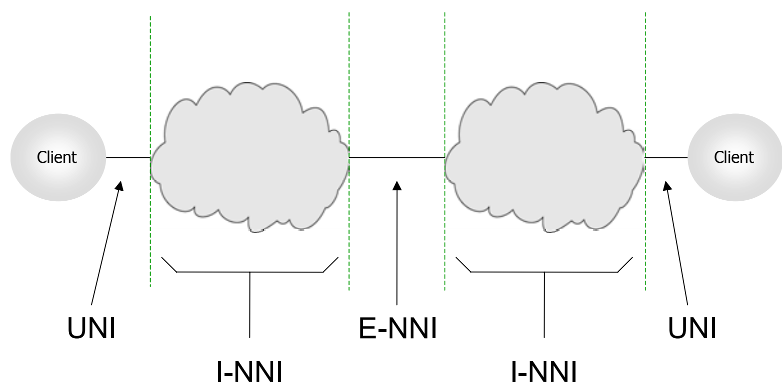

Figure 1: ASON Framework Reference Point Model

Control Plane Communications at ASON Reference Points

Across the reference points, control plane information flows support the following functions:

- Resource Discovery
- Call Control
- Connection Control
- Connection Selection
- Connection Routing*

**Connection routing is only applicable at the I-NNI and E-NNI. No routing functions are associated with the UNI reference point. Furthermore, at this time, no specific routing protocols are mandated by ASON.*

In each case, additional functions (such as security, call authentication, and enhanced directory services) may be provided to augment basic functionality.

ASON allows the use of the G.7713.2/Y.1704.2 signaling protocol (4), which is the same as IETF RFC 3473 (5), at the UNI reference point (between the optical client and the OTN) and at the E-NNI reference point (inter-domain). ASON does not define any requirements for I-NNI routing or signaling. Sycamore Networks supports the use of G.7713.2/Y.1704.2 signaling at these reference points, and utilizes BroadLeaf™ signaling within the I-NNI. This approach is discussed in detail in the following sections.

Configuration in an ASON Compliant Sycamore Networks OTN

When the SN 16000 is deployed as part of an ASON compliant OTN (Figure 2), physical TE-links are provisioned at the UNI and E-NNI reference points.

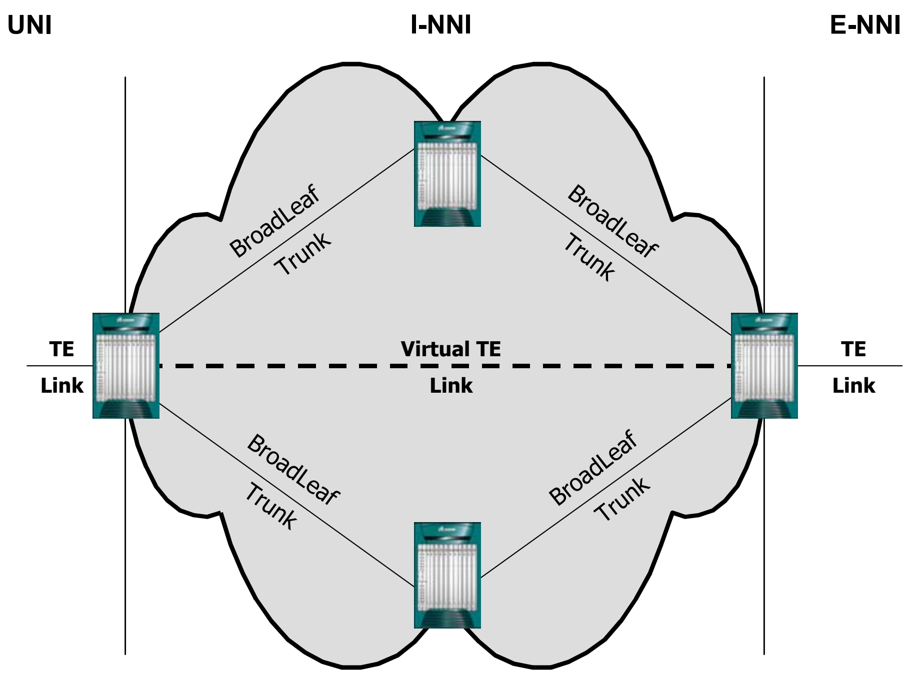

Figure 2: Physical and Logical Links in a Sycamore Networks ASON Compliant OTN

The physical elements within Sycamore's I-NNI consist of SN 16000 Intelligent Optical Switches and BroadLeaf Trunks. BroadLeaf Trunks are physical network links between adjacent SN 16000s that are created by specifying an SN 16000 SONET/SDH port as a trunk port. BroadLeaf peer discovery is used on BroadLeaf Trunks, allowing the SN 16000s to establish OSPF adjacencies, identify peer nodes, and build routing tables within the I-NNI.

Additionally, within the I-NNI, Sycamore implements Virtual TE-Links to identify logical adjacency between SN 16000 switches that physically host UNI attached client devices. Virtual TE-Links are logical links with no allocated physical resources; they simply provide virtual adjacency information. SN 16000 switches that do not support a UNI client device will not be configured with a Virtual TE-Link. Virtual TE-Links are provisioned via the SilvxManager® Virtual TE-Link tool.

Signaling in a Sycamore Networks Multi-Domain, ASON Compliant OTN

In the following example, a service provider is maintaining two domains within the OTN, with one domain supported by Sycamore Networks SN 16000s and the other domain supported by equipment from Vendor X (Figure 3). Client A is connected to SN 16000 S1 via a physical TE-Link. The Sycamore SN 16000s are physically interconnected, via BroadLeaf Trunks, as follows: S1←→S2, S1←→S4, S2←→S3, and S3←→S4. SN 16000 S1 is logically interconnected to SN 16000 S3 via a Virtual TE-Link. SN 16000 S3 is also connected to Vendor X network element (NE) X1 via a physical TE-Link.

G.7713.2/Y.1704.2 signaling is used at the UNI, and BroadLeaf routing and signaling is used within the Sycamore Networks I-NNI. G.7713.2/Y.1704.2 signaling, and some yet to be defined routing protocol, will be utilized at the E-NNI. An unknown signaling protocol, and possibly an unknown routing protocol, is used within Vendor X's domain. NE X2 connects to Client Z via a physical TE-Link and G.7713.2/Y.1704.2 signaling is used at the destination UNI reference point.

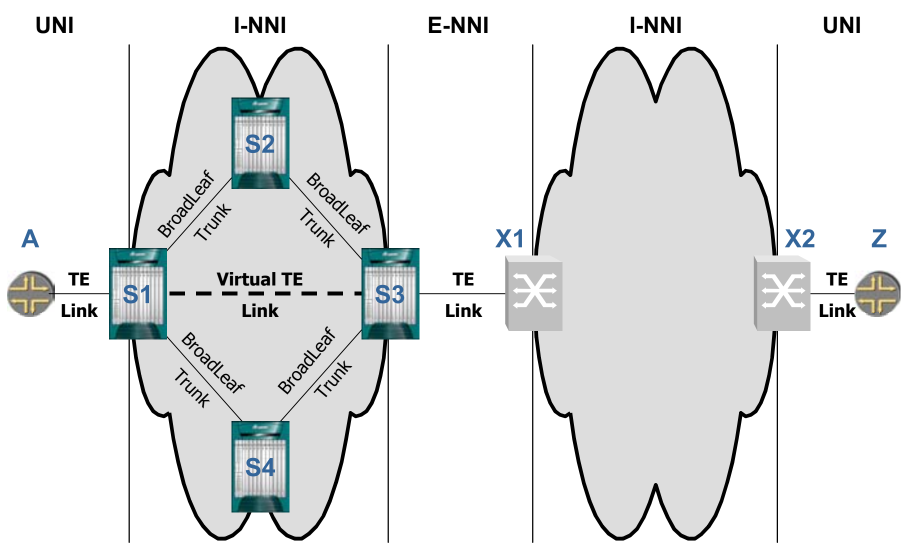

Figure 3: Physical and Logical Links in a Sycamore Networks Multi-Domain, ASON Compliant OTN

In this example, assume that Client A requires a connection to Client Z.

- Client A initiates a connection request via a G.7713.2/Y.1704.2 PATH REQUEST MESSAGE to SN 16000 S1.
- SN 16000 S1 examines the destination address contained in the SESSION_OBJECT of the PATH REQUEST MESSAGE, and identifies SN 16000 S3 as the next hop.
- SN 16000 S1 checks its local Link Table to see if TE-Links or Virtual TE-Links are available to SN 16000 S3. In this example (Figure 4), it will find a Virtual TE-Link, and it will extract the required control plane address information for SN 16000 S3 from the Virtual TE-Link provisioned parameters.

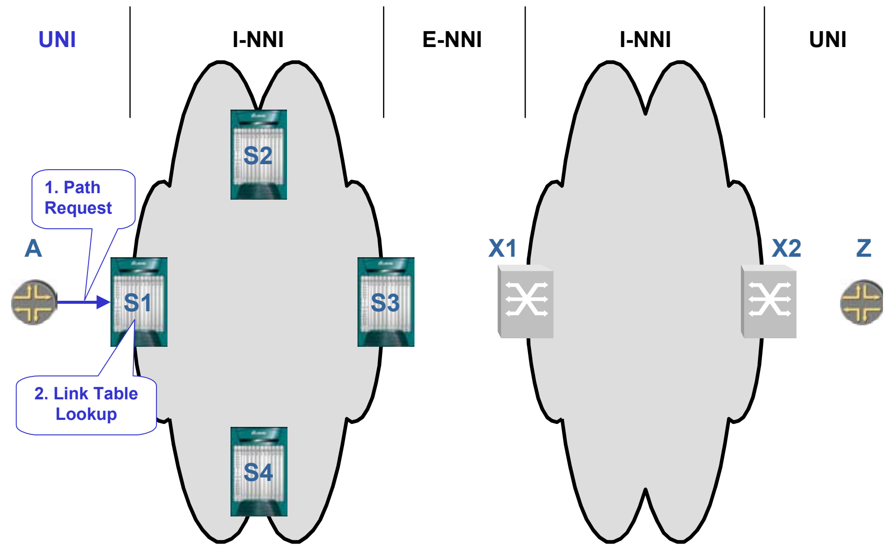

Figure 4: UNI Connection Request

- SN 16000 S1 forwards the G.7713.2/Y.1704.2 PATH REQUEST MESSAGE to SN 16000 S3, using the control plane address information identified in the previous step.

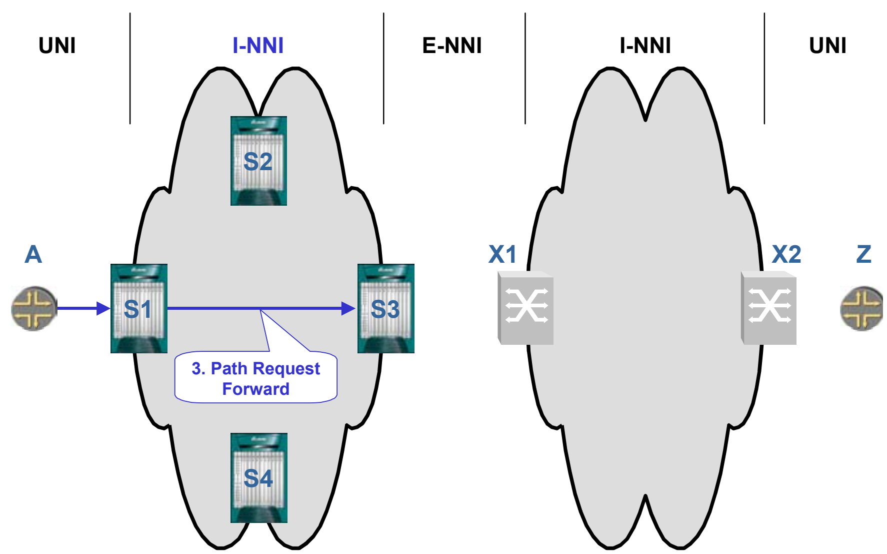

Figure 5. Path Request Flow, UNI through I-NNI

- SN 16000 S3 verifies that sufficient resources are available within the Sycamore Networks I-NNI by performing a constraint based shortest path calculation (CSPF-based). Via the path calculation, SN 16000 S3 discovers that a path exists to SN 16000 S1 via SN 16000 S2. SN 16000 S3 then sends a BroadLeaf PATH REQUEST MESSAGE to SN 16000 S1 via SN 16000 S2.

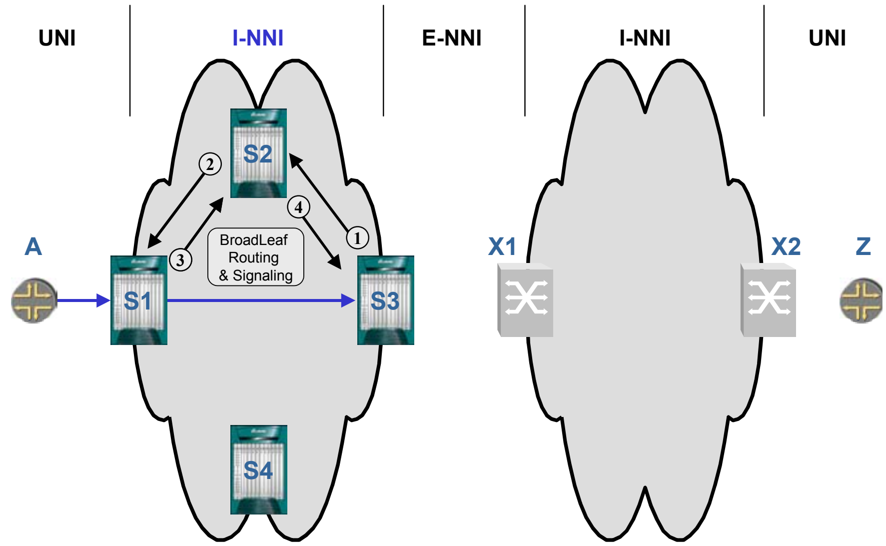

Figure 6. I-NNI Path Request and Acknowledgement

- Upon a successful response from SN 16000 S1, SN 16000 S3 examines the destination address contained in the SESSION_OBJECT of the PATH REQUEST MESSAGE, and identifies NE X1 as the next hop.
- SN 16000 S3 checks its local Link Table to see if TE-Links are available to NE X1. In this example, it will find a TE-Link, and it will extract the required control plane address information for NE X1 from the TE-Link's provisioned parameters.
- SN 16000 S3 forwards the G.7713.2/Y.1704.2 PATH REQUEST MESSAGE to NE X1, using the control plane address information identified in the previous step.

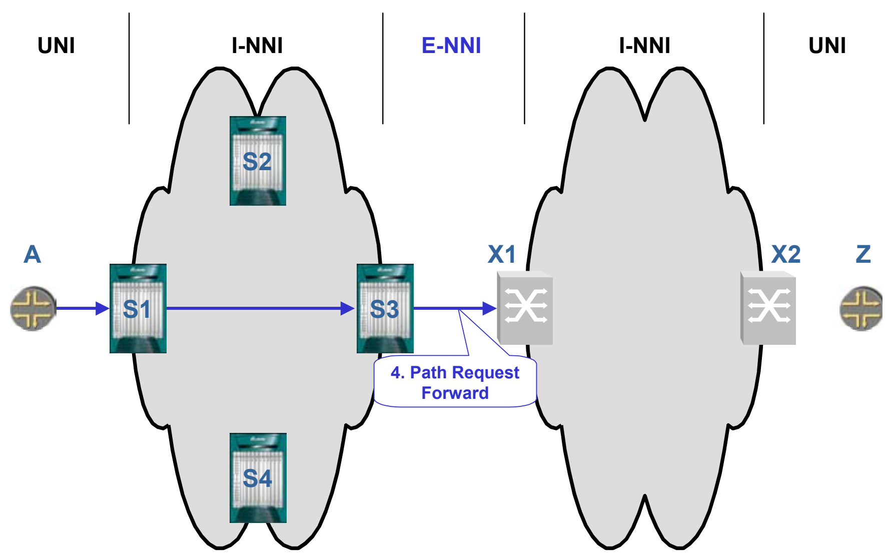

Figure 7. E-NNI Path Request

- Via an unknown I-NNI signaling protocol, and possibly a routing protocol, NE X1 will forward the PATH REQUEST MESSAGE to NE X2.

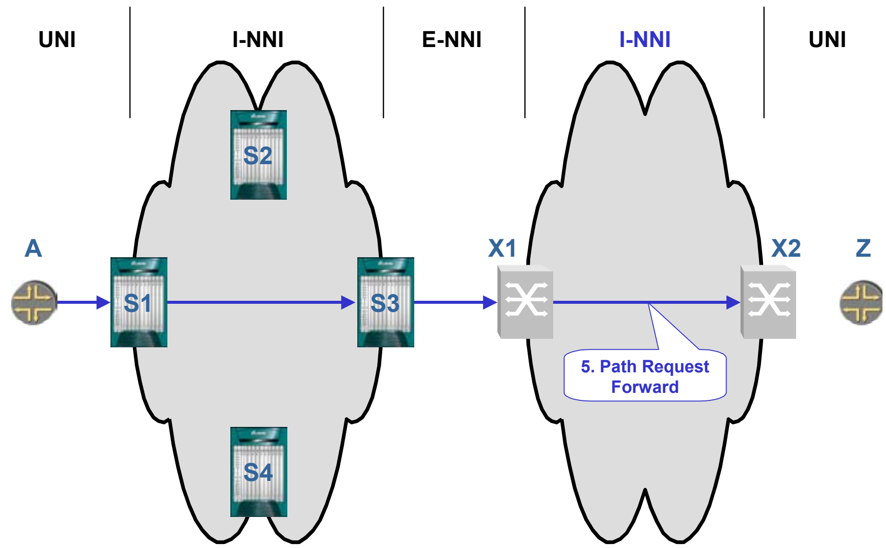

Figure 8. I-NNI Path Request (Vendor X Domain)

- NE X2 will forward the G.7713.2/Y.1704.2 PATH REQUEST MESSAGE to Client Z.

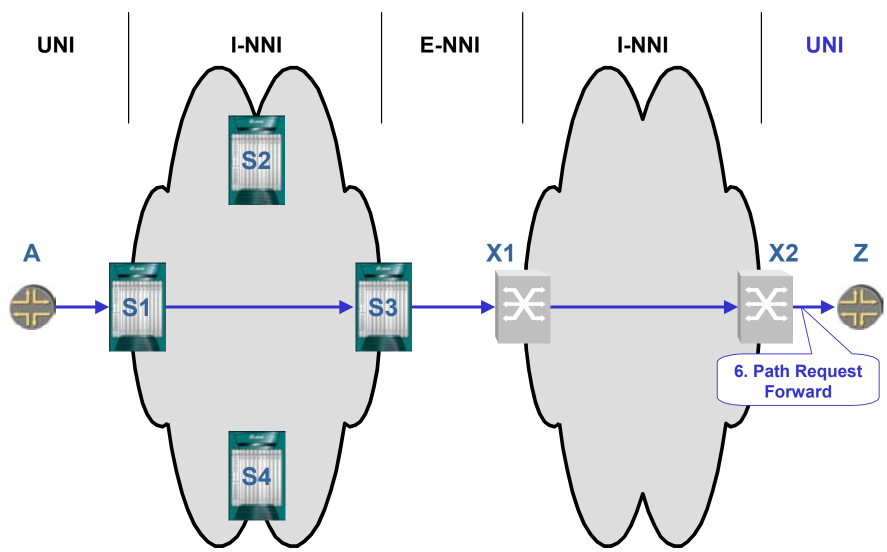

Figure 9. UNI Request Forwarding

- Client Z will then forward the G.7713.2/Y.1704.2 RESV MESSAGE to NE X2.
- NE X2 will then forward the G.7713.2/Y.1704.2 RESV MESSAGE to NE X1, via some signaling protocol.
- NE X1 will then forward the G.7713.2/Y.1704.2 RESV MESSAGE to SN 16000 S3.
- SN 16000 S3 will forward the G.7713.2/Y.1704.2 RESV MESSAGE to SN 16000 S1.
- SN 16000 S1 will forward the G.7713.2/Y.1704.2 RESV MESSAGE to Client A.

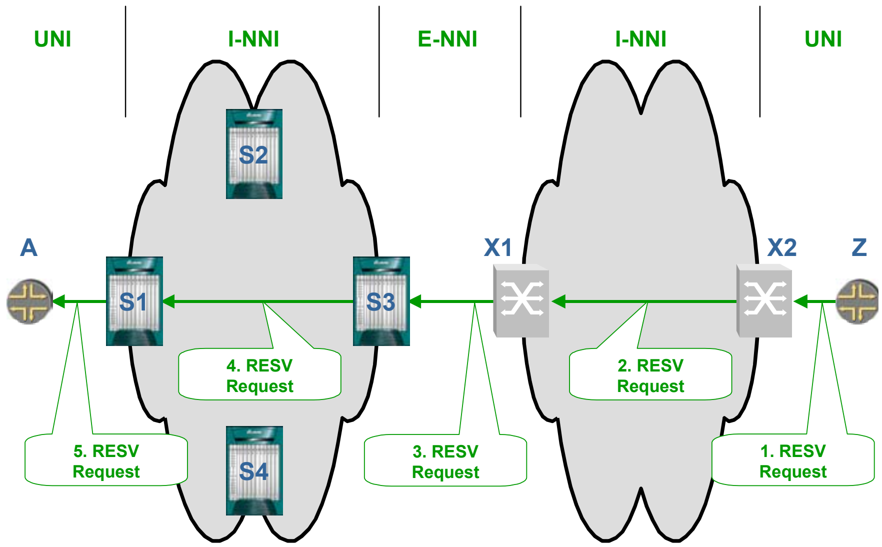

Figure 10. RESV MESSAGE Handling Process

The Label Switch Path (LSP) is now complete and data flow can begin.

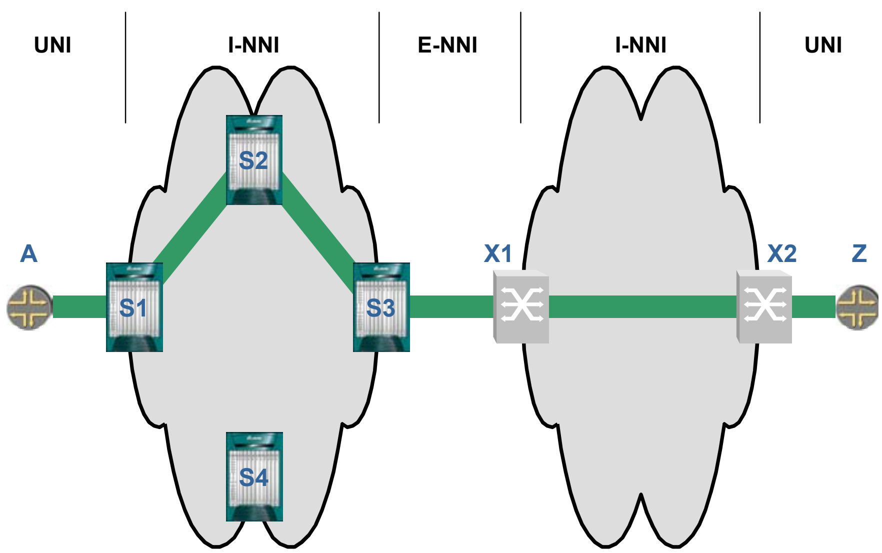

Figure 11. Completed A-Z Label Switch Path

Features of the BroadLeaf I-NNI

Features of the BroadLeaf based I-NNI include:

- Multiple, proven protection and restoration options
- Strong separation of optical and client domains
- Full integration with SilvxManager software portfolio
- Extensive public and private interoperability testing
- Based on operationally proven, feature rich networking software

Protection

BroadLeaf can resolve failures on a link of a circuit at the network level, using reroute restoration to establish a new end-to-end circuit; or at the local level, using trunk protection. These protection mechanisms can be applied to all signaled circuits, including those provisioned via G.7713.2/Y.1704.2 signaling. An important value-added feature is BroadLeaf's ability to combine multiple protection options within a given protection mode.

BroadLeaf supports the following circuit protection and trunk restoration options:

- **Unprotected:** No protection path is allocated; in the event of a path failure, the circuit remains pinned to its path and is failed until the problem clears.
- **Dynamic Path Restoration:** No protection path is allocated; if a path fails, the circuit is torn down and rerouted from the source node. Dynamic Path Restoration (sometimes referred to as mesh protection) eliminates the need to configure line or network-level protection, and optimizes the efficient utilization of network capacity.
- **1+1 Path Protection:** Both work and protect paths are allocated using shared resource link group (SRLG) constraints, ensuring work and protect paths are diversely routed through the network. Traffic is bridged to both work and protect paths, with the circuit endpoint selecting which path to use based on path health. 1+1 path protection can provide either a diversely routed circuit (DRC) or a conduit diversely routed circuit (CDRC). DRCs provide fully disjointed work and protect paths that do not share nodes, conduits, or links; CDRCs permit paths to share nodes.
- **Dynamic Span Restoration:** No protection path is allocated. In the event of a path failure, the failed portion of the path between two nodes is torn down and rerouted locally (that is, if a spare trunk is available between adjacent nodes). If no spare trunk exists, the entire circuit is rerouted from the source node.

Hybrid Network Model Options

In addition to supporting services in an ASON compliant Overlay Model, service providers may support services via a Peer Model. Concurrently supporting Peer and Overlay Models across the same optical network effectively creates what Sycamore Networks terms a Hybrid Model (Figure 12).

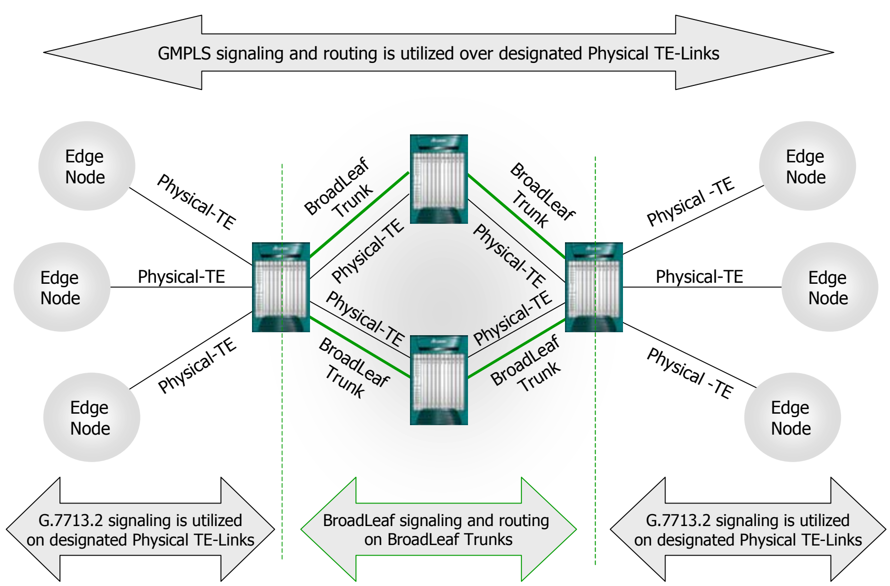

Figure 12. Sycamore Networks Hybrid Model

The Hybrid Model may be most useful in cases where a service provider supports a mix of services, some of which are requested directly by customer-controlled equipment, and some of which are requested from their own internally controlled equipment. In the case of customer-controlled equipment, ASON enhances network security by enforcing strong domain separation at the UNI and E-NNI. In the case of service provider controlled equipment, the service provider may deem that this equipment is within a 'trusted domain' and implement a Peer Model, which allows these devices to share a common signaling and routing instance with the OTN. Not only does this approach increase service and operational flexibility, it is non-disruptive from an OAM&P perspective, as G.7713.2/Y.1704.2 signaling is, in fact, IETF RFC 3473.

Conclusion

Sycamore Networks pioneered the concept of Intelligent Optical Networking: a highly flexible, more efficient optical network capable of supporting the data traffic driving network growth. Our vision remains focused on creating an agile and intelligent optical network that enables the efficient distribution of service bandwidth and provides a scalable foundation for long-term service differentiation and revenue growth for our customers. Our fully integrated, edge-to-core intelligent optical switching products reduce capital and operational costs, simplify network operations, and underpin a new generation of optical network services.

In pursuit of this effort, Sycamore has invested tremendous resources over several years to evolve our advanced optical control plane solutions into a true, carrier-class optical routing and signaling platform. These solutions leverage our extensive experience with BroadLeaf, which is operationally implemented in the largest meshed service provider networks in the world. Sycamore solutions have proven themselves in the demanding, data-centric network environments maintained by leading global carriers such as NTT Communications and Vodafone. Furthermore, our close alignment with emerging standard frameworks (ASON), protocols (GMPLS), and implementation agreements (OIF UNI/NNI) underscores our enduring commitment to open industry standards. Service providers can confidently invest in a BroadLeaf-based network, and count on our continued commitment to optical control plane developments and enhancements.

Sycamore understands that service providers require the non-disruptive preservation of traditional services and operational procedures while migrating to next generation solutions. Sycamore platforms are unique in their ability to support existing ring-based networks, while concurrently enabling a gradual, business-driven transition to more efficient, data-optimized optical networks, on a port-by-port basis.

Sycamore advocates a pragmatic, phased optical control plane adoption strategy underpinned by flexible, software-centric, and standards-compliant Intelligent Optical Switches. This approach allows customers to incrementally validate and turn-up control plane features without comprising network reliability or existing revenue streams. The Sycamore solution supports control plane communications in an Overlay Model, Peer Model, and Hybrid Model, to accommodate the broadest range of infrastructure and service requirements.

In summary, Sycamore Networks can flexibly and reliably support service providers' efforts to create advanced Intelligent Optical Networks. Our solutions enable service providers and very large enterprise organizations to efficiently manage and utilize network capacity, and economically deliver high-speed bandwidth services.

References

1. G.8070/Y.1302 Requirements for Automatic Switched Transport Networks
2. International Telecommunications Union (ITU), www.itu.int
3. ITU-T G.8080/Y.1304 Requirements for Automatic Switched Optical Networks
4. G.7713.2/Y.1704.2: DCM Signaling Mechanism Using GMPLS RSVP-TE
5. RFC 3473: GMPLS Signaling RSVP-TE Extensions

About Sycamore

Sycamore Networks, Inc. (NASDAQ: SCMR) develops and markets intelligent optical networking products for the telecommunications industry. Sycamore's optical switching products form the network foundation for some of the world's most respected and innovative service providers. The Company's fully integrated, intelligent network solutions enable its customers to reduce network costs, simplify operations, and deliver a new generation of high-speed network services. For more information, please visit www.sycamorenet.com.

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