WHITE PAPER

Deploy a Robust Transport Control Plane with ASON-GMPLS

Tellabs uses the ASON Architecture to enhance GMPLS deployment.

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Executive Summary

Generalized Multiprotocol Label Switching (GMPLS) is an Internet Engineering Task Force (IETF) initiative aimed at applying Internet Protocol/Multiprotocol Label Switching (IP/MPLS) automation techniques to the control of transport networks. However, IP/MPLS protocols sometimes rely on assumptions that are not valid in transport applications. So while GMPLS may work in the lab, it has limitations when deployed in live service provider networks. The Automatically Switched Optical Network (ASON) is an International Telecommunication Union-Telecommunication (ITU-T) program based on extensive transport networking experience that defines control plane requirements for service provider transport networks, as well as an architecture for meeting the requirements. However, ASON does not specify all of the protocol details necessary to implement a control plane solution.

Alone, both GMPLS and ASON are incomplete, but the Optical Internetworking Forum (OIF) has combined them to provide a solid control plane solution. The OIF is a group composed of national and international network service providers and leading equipment vendors. The goal of the OIF is to develop Implementation Agreements (IA) to guide the application of various technologies to optical transport. Tellabs has taken a leadership role in developing OIF control plane IAs and promoting interoperability testing of OIF-based solutions.

The Tellabs control plane meets OIF protocol IAs, and Tellabs has participated in many OIF interoperability events that have demonstrated broad industry support for the OIF IAs. Beyond meeting OIF agreements, the Tellabs control plane solution includes additional enhancements such as Abstract Node, Multilayer Routing and Identifier Separation. These features are designed to handle a variety of transport network deployment and evolution scenarios. The Tellabs control plane solution offers service providers the tools they need to effectively deploy, operate and evolve control plane-enabled transport networks.

Introduction

Transport service providers are looking to improve the cost-effectiveness of transport network operations by applying automated control protocols in a variety of roles, including discovery of network links, distribution of topology information, calculation of service routes, signaling to establish service connections, protection and restoration, etc. This automation has the potential to decrease both the number of operator "touches" required to implement transport services and Network Management System (NMS) complexity, thus reducing the cost of NMS development or acquisition. Control plane automation also offers added resiliency to transport services by enabling dynamic reroute recovery. These benefits drive the desire to deploy control plane-enabled transport networks.

GMPLS is a set of proposed standards — IETF Requests for Comment (RFC) — aimed at meeting this need. GMPLS addresses various aspects of applying signaling and routing protocols originally designed for IP/MPLS networks to the control of transport networks. With GMPLS, the IETF is incrementally attacking the problem of distributed control of transport networks. Each RFC addresses an aspect of the problem and, as a group, the GMPLS RFCs provide a starting point for implementing an interoperable control plane solution. However, there are aspects of transport network operation that the IETF has not yet addressed, so currently GMPLS by itself does not provide a complete, carrier-class transport control plane solution.

ASON is a set of international standards — ITU-T Recommendations — that define requirements and architecture for distributed control of transport networks. This work draws on the extensive expertise of the ITU-T participants in transport network functional and operational standards. The intent of the ASON standards is to provide a framework for the development and deployment of control plane applications in transport networks.

The OIF has used the ASON recommendations to apply GMPLS protocols to practical transport network control problems defined by its service provider participants. These service providers, together with OIF's vendor participants, have produced IAs describing how the GMPLS protocols can be used. The OIF IAs have been the basis for a series of successful global interoperability events that have demonstrated the capabilities of distributed transport network control.

This white paper discusses the key aspects that should be considered when selecting, deploying and operating a transport control plane. Tellabs has been involved in transport network control standardization from its inception and continues to play a leading role in the OIF effort to apply control plane standards that meet service provider needs. The Tellabs ASON-GMPLS control plane builds on the work of the ITU-T, IETF and OIF. By incorporating additional enhancements, Tellabs has produced a best-in-class solution for service providers.

Deploying a Control Plane-Enabled Transport Network

A carrier class transport control plane should provide a service provider with the necessary tools to effectively automate network operation over the lifetime of a transport network. There are three major stages of operation and each places its own demands on a control plane solution. First, the control plane should provide features that enable a service provider to install, provision and initialize the protocols that will operate the network. Second, the control plane should provide effective day-to-day operation and interoperation with peer networks and customers. Finally, the control plane should provide features that allow a service provider to manage the natural growth and re-optimization of the network without undue impact to established services or operations.

The following sections address each of these stages and describe the GMPLS and ASON features that enable the Tellabs control plane solution to meet operational challenges at each stage.

Getting the Network Started

A transport control plane automates many provisioning and fault recovery operations. However, before these operations can be automated the control plane itself must be designed and deployed. This effort includes configuring the Signaling Communications Network (SCN), organizing routing areas and establishing protocol peering relationships.

Provide a Flexible and Secure SCN

SCN design affects the reliability, performance and security of the control plane. Experience has shown that out-of-band control networks provide excellent security and resilience, as exemplified by SS7 control network design. In some cases, however, in-band or associated control channels are required to reach network elements not easily reached by out-of-band SCN links. Therefore, it is important that control protocols work in both out-of-band and in-band communication scenarios. Furthermore, communication channels may be shared with management communication traffic and service provider policy may dictate that this arrangement not adversely impact control plane performance. Thus, SCN design is an important aspect of control plane deployment.

GMPLS does not directly address SCN design considerations, but it assumes an IP SCN is in place. GMPLS protocols do support out-of-band communication options and it is important to implement these options in a carrier-class solution — for example, the Open Shortest Path First (OSPF) point-to-multipoint option. Additional transport SCN design guidance is provided by ASON recommendation G.7712, including IP SCNs and the use of transport link associated channels. ASON also addresses the need to isolate management and control plane communications from each other using either physical or logical separation.

The Tellabs control plane solution builds on G.7712 and includes SCN design consulting for transport service providers. The Tellabs solution supports in-band and out-of-band communications in a common infrastructure employing IP reroute. This approach enhances robustness by adding network-based resilience options beyond simple channel protection between protocol peers. It also simplifies SCN design and operation because in-band or associated channels are managed the same way as other SCN links and do not require special maintenance protocols like the GMPLS Link Management Protocol (LMP), for example. Finally, Tellabs adds priority queuing mechanisms to help maximize control plane performance while allowing physical resources to be shared by control and management communications networks.

Support Hierarchical Routing Area Design

In the control plane, topology information distribution and route calculation are organized around routing areas. Routing area design impacts route calculation performance and scalability and controls the visibility of network topology. The ability to organize routing in a multi-area routing hierarchy provides an effective, scalable and secure solution for managing transport network topology information in multi-layer, multi-vendor and multi-carrier scenarios.

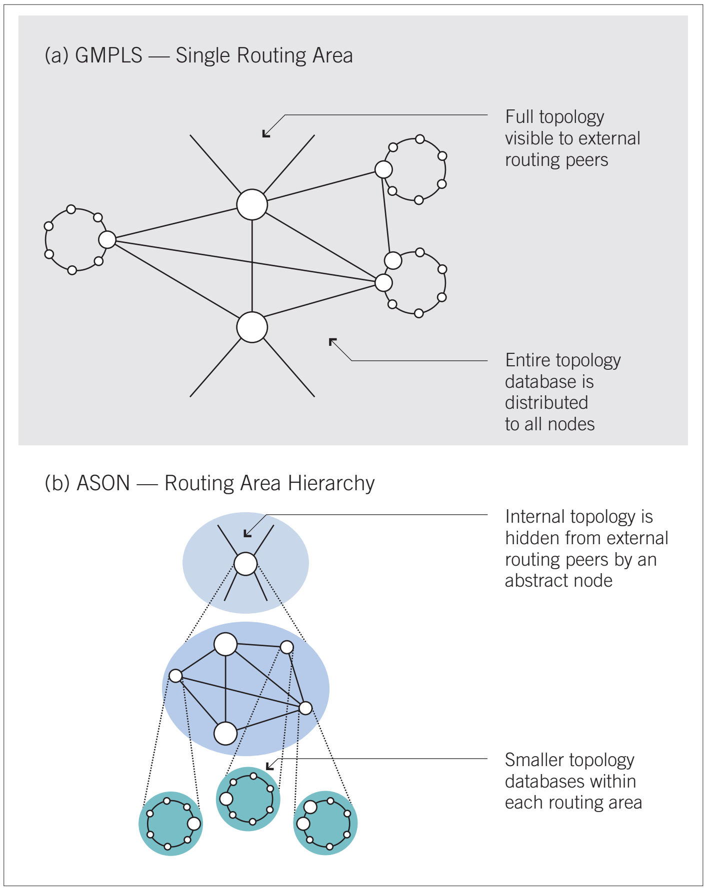

Figure 1. Routing area design

GMPLS currently specifies routing for traffic-engineered paths in a single routing area[1] and work is underway to broaden GMPLS to include multi-area routing. As a result, some current GMPLS implementations support only a single routing area (Figure 1a).

ASON specifies a routing area hierarchy that provides a flexible and scalable model for organizing transport network routing areas. This approach has several advantages. A routing area hierarchy can be used to organize transport routing around domains based on technology, equipment vendor, topology, geography, operational groups or combinations of these considerations. Following the ASON model, the Tellabs implementation builds upon existing GMPLS routing protocols and supports a multilevel routing area hierarchy with link state routing at each level (Figure 1b).

Subordinate routing areas may be represented as "abstract nodes" in higher level routing areas, which provide several benefits:

- Hide details of the subordinate area
- Reduce the size of topology databases
- Improve route calculation time
- Minimize "churn" in topology databases

Abstract nodes also serve to hide internal details of a service provider's network from peers while providing sufficient routing information to enable constraint-based route calculation.

The Tellabs approach of using GMPLS protocols within the ASON architectural framework provides the necessary tools for a service provider to organize and operate an effective, secure and scalable routed transport network.

Establish Appropriate Peering Relationships

With an SCN in place and routing areas configured, the next step in setting up the control plane is to establish protocol peering relationships for the links in the network. There are three common types of peering relationship: User to Network Interface (UNI), Internal Network-to-Network Interfaces (I-NNI) and External Network-to-Network Interfaces (E-NNI). UNI relationships are established between the transport network and its clients (users). I-NNIs are used between nodes with homogenous operations policies, usually within individual domains in a service provider's network. E-NNIs are used between nodes with heterogeneous operations policies, for example between different service providers' domains, different vendors' domains, different technology domains, etc.

GMPLS defines an NNI within a single operational domain (Figure 2a). This provides the basic control functions for transport routing and signaling. However, service providers also typically require support for trust and/or visibility boundaries provided by UNI[2] or E-NNI interfaces.

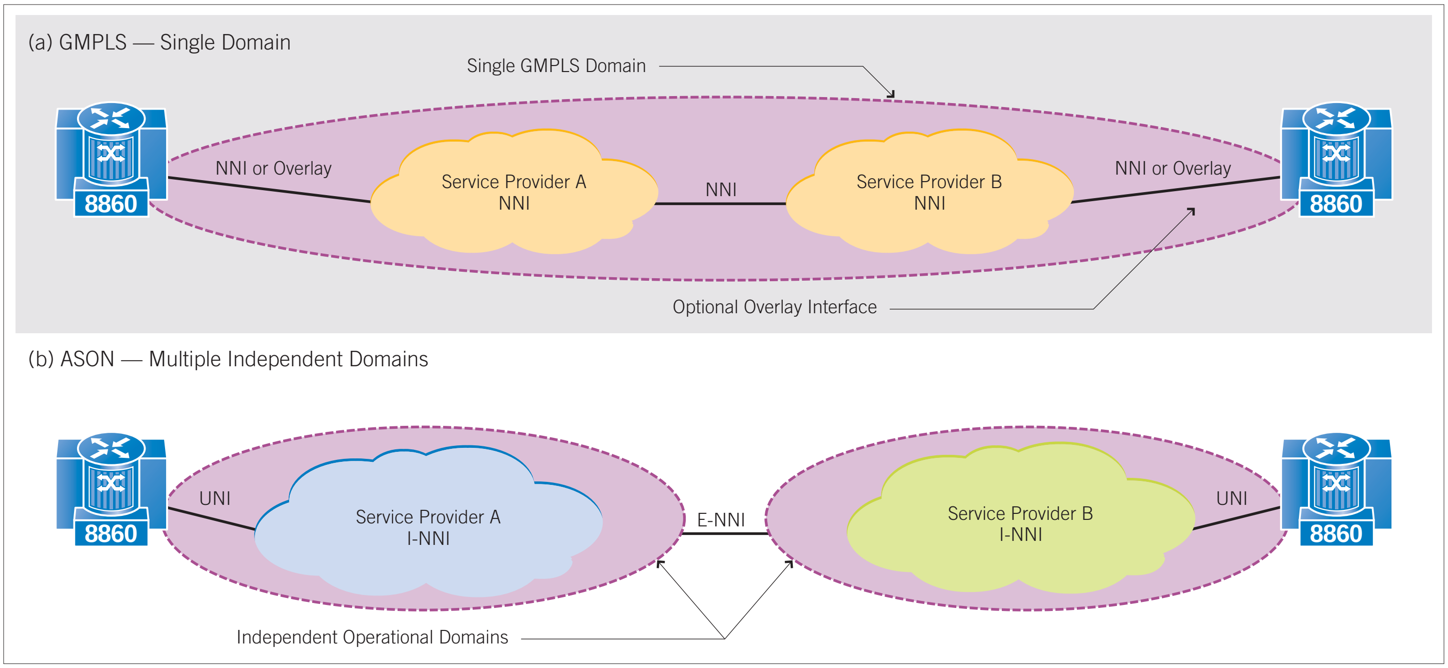

Figure 2. Peering and domain independence

[1] While OSPF supports multiple routing areas for IP, GMPLS OSPF-TE has not yet defined multiple routing area support for TE applications.

[2] GMPLS does define a restricted form of the NNI behavior called "GMPLS Overlay" (sometimes referred to as a "GMPLS UNI") but this does not provide sufficient flexibility or independence for all service provider applications.

The ASON architecture addresses all three interface types and the OIF has developed and tested interoperability IAs for both UNI and E-NNI interfaces meeting ITU architectural requirements (Figure 2b). The features of the OIF UNI and E-NNI interfaces enable a greater degree of independence and require less operational coordination between domains. With these extensions, a complete solution is provided — supporting security and information hiding requirements at customer and service provider peering interfaces.

The Tellabs control plane solution supports all three interface types, with an I-NNI designed to support ASON requirements. Furthermore, the Tellabs ASON-GMPLS control plane can interwork with GMPLS-only control plane solutions. However, GMPLS-only domains may lack the additional advantages offered by the ASON architecture.

Provisioning Service

Once the transport control plane has been provisioned and initialized, it can be used to conveniently establish transport service connections from a single point of control. The routing subsystem distributes topology information in the form of Link State Advertisements (LSAs) throughout each routing area. Once the topology database has been distributed, service connections can be provisioned. Service provisioning involves a combination of route calculation and signaling to establish the connections that implement a service.

Ensure Accurate Routing

The GMPLS routing protocol most often used in transport applications is OSPF. GMPLS defines an OSPF LSA that is sufficient in simple transport applications. However, many transport applications, especially those likely to arise in larger or more established transport networks, require a more precise transport network model. Using ASON principles, the OIF has extended the OSPF LSA to more precisely describe the transport network structure and has used it successfully in several OIF interoperability demonstrations. This LSA improves the accuracy of route calculations and increases the likelihood that a selected route will work in practice.

The Tellabs E-NNI and I-NNI routing protocols utilize the OIF LSA to support excellent routing performance and help maximize the routing success rate, while minimizing the need for crankback or other retry strategies. As previously discussed, the Tellabs abstract node routing subsystem also hides a service provider's internal network topology while providing a top-level link state routing database suitable for use in constraint-based route calculation among peers.

Use Names to Provide Address Independence

GMPLS service routing is predicated on reaching a destination address within a routing domain. ASON enhances service routing by adding the concept of destination *names* that are independent of the network addressing scheme. Customers or peer service providers may then use these names to refer to service destinations rather than relying directly on network addresses. This enables service providers to use private addressing schemes within their routing domains and manage these addresses without impacting customers or peer service providers. It also enables a customer to change locations, and thus change network attachment points, while retaining the same destination name regardless of a change in network address.

In the OIF IAs, destinations can be identified using Transport Network Assigned (TNA) names and destination TNA names can be translated into a true network address when the service request is received by the control plane. If a customer changes locations e.g. moves to a new building) and subsequently changes the network attachment point, only the TNA translation must be updated to allow the customer to keep the original "address" — there is no effect on the actual network addressing plan. This process operates in a manner similar to that used to support 800 toll-free number phone services.

The same technique can also be used to allow address independence between service providers, as the destination TNA can be retranslated when entering each service provider's network (Figure 3). The first TNA translation (Service Provider A) would yield a destination address of "Service Provider B's network." Upon entering Service Provider B's network, the TNA is translated again, yielding a specific endpoint address in Service Provider B's network.

The Tellabs control plane solution supports the use of destination names and addresses for GMPLS compatibility in a flexible architecture that, if desired, can be easily extended to support additional name formats, such as Internet Universal Resource Identifiers (URIs).

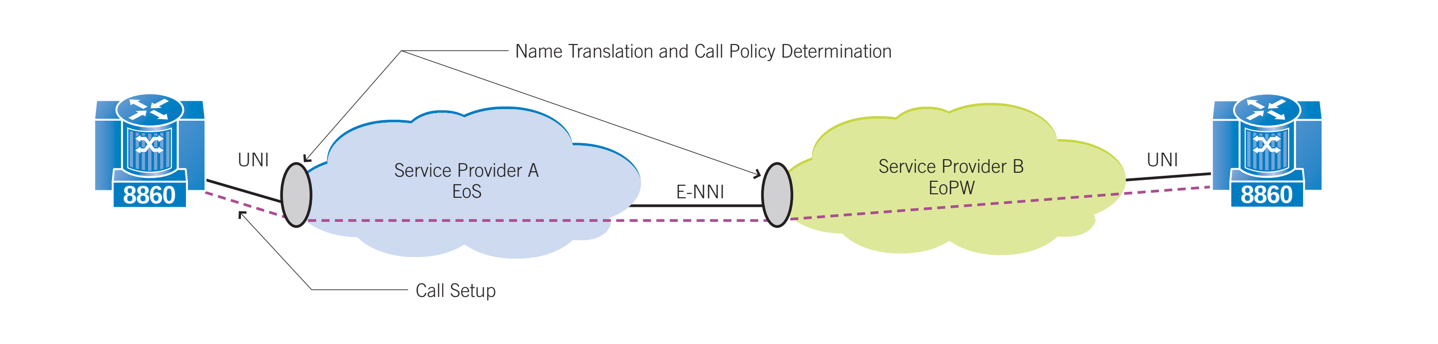

Figure 3. ASON – Independent domain policies

Enable Service Transparency

GMPLS was initially conceived as a way to automate connection setup and many transport services are simply "connections." ASON goes a step beyond and defines the concept of a "call" representing a service instance as distinct from a simple connection. This enables control of more complex service models, for example Ethernet over Synchronous Optical Network Technologies/Synchronous Digital Hierarchy (SONET/SDH). The OIF UNI extends the GMPLS Resource Reservation Protocol-Traffic Engineering (RSVP-TE) signaling protocol with call request information that, upon entering a domain, is interpreted to determine the destination and connection type required to provide the requested service. This allows separate domains to implement different policies to support a given service.

For example, Service Provider A may support Ethernet private line service using Ethernet over SONET while Service Provider B supports the same service using pseudowire (Figure 3). Within Service Provider A's network, an Ethernet call may be supported by multiple SONET/SDH connections (e.g. Virtual Concatenation (VCAT). In Service Provider B's network the same Ethernet call may be supported using a single Transport MultiProtocol Label Switching (T-MPLS) LSP. This policy selection is implemented at the service provider boundary by a call controller that interprets the call request information and initiates the necessary connection requests to implement the service. ASON's call and connection separation, like the abstract node concept, enables service provider independence between domains and significantly simplifies peering.

With call and connection separation in mind, the Tellabs control plane solution re-interprets call request parameters at domain boundaries to enable shifts in service or operations policy between domains. Service providers thus have the tools necessary to implement flexible and interoperable control policies that meet the needs of the various domains in their transport network while remaining independent of policies chosen by their peers.

Migrating and Evolving the Network

As a transport network grows and evolves, a variety of changes can occur that affect the control plane. A successful service provider may find their network growing to the extent that new routing areas must be created or existing routing areas partitioned to maintain scalability and performance. Service providers may also merge and consolidate their transport networks, or one service provider may acquire the assets of another service provider and need to integrate them into an existing transport network. Each of these changes affects the control plane, making it essential to have the right tools in place to handle these situations with the least possible disruption to services and operations.

Enable Domain Address Independence

GMPLS does not offer specific mechanisms designed to assist in these kinds of large-scale network modifications. ASON has anticipated the need for these types of efforts and the ASON architecture provides a structure within which network modification and re-optimization can be accomplished with minimal impact on ongoing operations.

For example, the ASON architecture supports separate and independent addressing in each routing area if desired. This enables service providers to reorganize the addressing plan in one domain without affecting other domains. If there is a need to merge two networks that have used the same addressing space, the address independence feature can maintain distinct addressing domains until address re-assignment can be completed.

Maintain Functional Identifier Separation

In addition to transport resource names and addresses, control plane protocols use a variety of other identifiers to refer to objects in the transport plane, control plane and SCN. For example, routing requires the following identifiers:

- *Node ID* — Identifies a transport network node, a vertex in the topology database
- *Router ID* — Identifies a routing protocol component, a source of LSAs
- *Router SCN Address* — Identifies the SCN location of a routing protocol component

Based on its IP heritage, GMPLS allows IP SCN addresses to be used in many roles, including as Router IDs and Node IDs. This can initially be a convenience, as fewer identifiers are required to be specified in provisioning the control plane.

However, clearly separating identifiers enables flexible design and deployment of control plane components. The ASON architecture specifies distinct identifiers for each specific purpose. This ensures that network modifications, like merging networks that have both used the same SCN address space, can be accomplished with minimal disruption. With separate identifiers, router SCN addresses can be changed to eliminate duplication in the SCN without changing Node IDs or Router IDs, avoiding widespread changes in the transport network topology database and connection route records.

The Tellabs control plane maintains clear identifier separation, so while different identifiers may take on the same value initially for operational convenience, they may be changed independently as the networks evolve.

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Conclusion

Transport service providers want to deploy control plane technology to cost effectively operate the new generation of integrated optical transport networks. The IETF and ITU-T are contributing their expertise toward this goal, and the OIF is putting the pieces together to define IAs that meet identified service provider needs. Tellabs is active in all these areas and is providing leadership in the OIF effort to apply control plane technologies to solve the many practical problems service providers face. The table below summarizes how Tellabs has leveraged GMPLS, ASON and unique operational enhancements to create a carrier-class transport control plane solution.

The Tellabs control plane is built on the base protocols defined by GMPLS. ASON provides a carrier-class architecture that enables service provider independence while maintaining the necessary level of interoperability. The OIF has taken the GMPLS protocols and defined interoperability agreements that embody ASON architecture principles, such as address independence and multilevel routing hierarchy. To finish the job, Tellabs has developed a standards-compliant implementation that provides support for additional operational enhancements consistent with the ASON architecture. The result is a control plane that provides the tools necessary to effectively handle the variety of transport network deployment, operations and evolution scenarios that a network service provider may face.

	GMPLS (IETF) *Foundation*	**ASON (OIF)** *Solution*	**Tellabs** *Enhanced Solution*
Flexible, Secure SCN	—	SCN Options Specified	Uniform and Flexible SCN
Routing Area Design	Base Protocol (OSPF)	Area Hierarchy	Multi-Level with Abstract Node
Peering Relationships	Single Carrier (NNI)	Customer (UNI), Multicarrier (E-NNI)	Peering Policy Enforcement
Routing Accuracy	Generic Bandwidth Model	Accurate Transport Model	Multi-Layer Routing
Names and Addresses	IP Address Model	Name/Address Model	Name Portability
Service Transparency	(work underway)	Call/Connection Architecture	Border Policy Enforcement
Migration/Evolution	—	Separation of Architectural Concerns	Identifier Separation

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