

---

**ADDRESSING INTER PROVIDER CONNECTIONS  
WITH MPLS-ICI**

---

**INTRODUCTION**

The migration away from traditional multiple packet overlay networks towards a converged packet-switched MPLS system is now well advanced in most carrier networks. There are many varied business drivers behind this migration. Service providers are seeking to reduce network costs. In addition, MPLS core networks enable the delivery of new network services and will support new multi-media content with QoS requirements.

This evolution in the network has coincided with the increasing communications needs of large enterprise customers, including the need to seamlessly connect various global locations. Service providers must interconnect their new MPLS-based networks with partner providers in order to fulfill enterprise demands for global connectivity

This is currently achieved only via bilateral agreements and is limited to basic IP interconnect. In order to provide a framework to facilitate these agreements and expand the scope of MPLS interconnects to carry a variety of Layer 1, 2 and 3 services, the IP/MPLS Forum, with input from its service provider members, has developed a specification that addresses the full spectrum of interconnect issues. These include methods for the establishment of Label Switched Paths (LSPs); signaling and routing protocols; resiliency; traffic management and Quality of Service (QoS); Operations, Administration and Maintenance (OAM); as well as packet forwarding and security requirements.

The resulting MPLS Inter-Carrier Interconnection (MPLS-ICI) Technical Specification will be a vital tool in reducing service providers' costs and adding value to their customers by enabling "next-generation" services such as VoIP, IPTV, Layer 2 VPN, IP VPN and many other services on a seamless, global basis.

The MPLS-ICI Technical Specification addresses four common MPLS services: inter-carrier BGP/MPLS IP VPN services, labeled IPv4 routes, pseudowires (emulated Layer 1 and Layer 2 services over an MPLS network) and traffic engineered trunks. Each of these has unique requirements and may use different routing protocols. The main body of the Technical Specification addresses those requirements common to all these uses. Normative Annexes address requirements that are specific to each of the services.

The IP/MPLS Forum bases its work, where possible, on existing or developing standards and, working with other standards bodies, amends or adds to them as needed to create a particular solution. The services addressed in the MPLS-ICI Technical Specification make use of existing standards for signaling, routing and OAM mechanisms. It is anticipated that later versions of the specification may include methods to dynamically reroute multi-segment pseudowires and other advanced OAM capabilities as these are matured. Requirements for new applications or services may also be considered.

This white paper outlines the commercial drivers contributing towards the need for the MPLS-ICI Specification, describes the service applications for MPLS-ICI and the architecture outlined in the Technical Specification, and touches on some of the unique challenges and issues addressed in the Specification.

**CONTENTS:**

<b>Introduction .....</b>	<b>1</b>
<b>Market Trends Driving Demand for MPLS-ICI.....</b>	<b>2</b>
<b>Overview of Inter-Carrier MPLS Services .....</b>	<b>2</b>
<b>Inter-AS BGP/MPLS IP VPNs.....</b>	<b>2</b>
<b>Labeled IPv4 Routes.....</b>	<b>3</b>
<b>Pseudowires .....</b>	<b>3</b>
<b>Inter-Provider TE Tunnels .....</b>	<b>4</b>
<b>Applications in Summary .....</b>	<b>5</b>
<b>MPLS-ICI Architectural Overview .....</b>	<b>5</b>
<b>Challenges and Solutions .....</b>	<b>6</b>
<b>Summary and Conclusions.....</b>	<b>7</b>

## MARKET TRENDS DRIVING DEMAND FOR MPLS-ICI

---

Carriers around the world have made significant progress in converging multiple networks and services onto a single, high-speed IP/MPLS core. There are a number of drivers for this:

1. **Reduced capital expenditures (CAPEX):** Reduce the number of networks by converging several independent networks over a common IP/MPLS network.
2. **Reduced operating expenditures (OPEX):** Fewer networks to manage results in less operational staff, fewer systems and therefore less operational cost.
3. **Improved Return on Investment (ROI):** One network that supports multiple services will recoup its costs faster, compared to several separate networks.

In addition, service providers have been offering innovative, new services on their MPLS backbones. MPLS has been widely used to enable IP VPNs and Traffic Engineered (TE) data trunks, but new network services such as pseudowires and BGP labeled routes are emerging in service provider networks. User applications such as Layer 2 Virtual Private Networks (L2VPNs), IMS/VoIP, IPTV, gaming and other multimedia services may utilize the MPLS network services.

As these services have become more widespread, another trend has emerged. The growing communications needs and wide geographic spread of large multinational enterprises has meant that service providers have been required to provide enterprise customers with worldwide network capabilities allowing these customers to connect their sites, as well as connect to their suppliers, partners and customers globally. However, while many large corporations have a truly international footprint, the same cannot be said of all service providers. In addition, some enterprises consciously choose not to rely on a single source network provider. For these reasons, large enterprises are driving the need for service providers to interconnect their networks in order to achieve the desired global connectivity and to offer a ubiquitous and seamless services experience.

Most existing interconnections between service providers are used for either the transport of IP packets on IP interconnections or for the transport of native Layer 2 services such as ATM and Frame Relay over standards-based NNI connections. Interconnections between carriers' IP/MPLS networks, however, have to date been somewhat limited, due to MPLS's relative newness in the marketplace, and the complexity of some of the issues described. Some pioneering carriers have established MPLS peering via bilateral agreements, which are business arrangements negotiated between the two carriers. MPLS-ICI does not eliminate the need for bilateral agreements, but will simplify the negotiation process.

The MPLS-ICI provides the technical specification component of such an agreement for interconnecting service provider networks using IP/MPLS. A standards-based definition of such an interconnection allows services to be transported over MPLS from one provider edge to the other provider edge in a secure, consistent and transparent manner. In addition, because MPLS is a multi-service transport technology, an MPLS-ICI eliminates the need to have multiple interconnect technologies at the carrier connection points, enabling carriers to simplify network, reduce OPEX and CAPEX, and improve ROI. These are the same factors that initially motivated carriers to deploy MPLS for their converged packet backbone networks.

**MPLS-ICI addresses several network services between two providers, including:**

- **VPN services (Inter-AS Border Gateway Protocol (BGP)/MPLS IP VPNs)**
- **LSPs for IPv4 routes using BGP, that is, labeled IPv4 routes**
- **The creation of MPLS pseudowires to transport Layer 2 (ATM, Frame Relay, Ethernet) virtual circuits (VCs)**
- **TE data trunks to carry traffic (e.g., voice) that has specific bandwidth requirements and QoS attributes.**

## OVERVIEW OF INTER-CARRIER MPLS SERVICES

---

Some requirements of an MPLS interconnection are common to all its uses, but it is recognized that for others, different services traversing the MPLS-ICI may have differing requirements (or preferences). This is not intended to be an exhaustive list of services, but to provide an explanation of the most common early uses for an MPLS-ICI.

### INTER-AS BGP/MPLS IP VPNs

Many service providers offer IP VPN services to their enterprise customers and want to sell these services to global enterprises, even if they do not offer local services in all the geographic territories where these enterprises are active.

Figure 1 illustrates one method by which two Service Providers exchange enterprise customer routes between Autonomous System Border Routers (ASBRs) in order to provide IP VPN

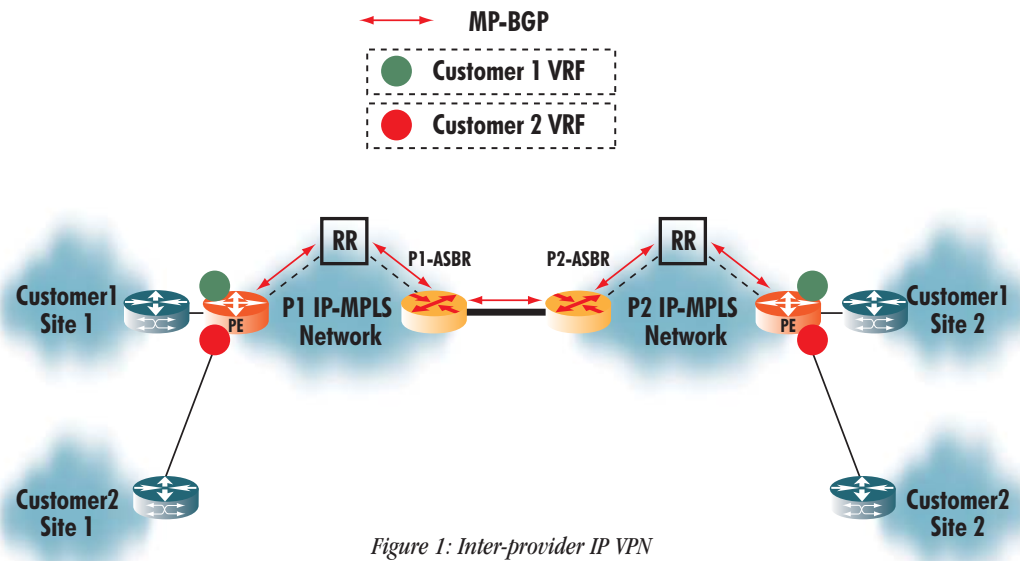


Figure 1: Inter-provider IP VPN

service between locations that are served by different service providers' networks. This method is known as "Option B" in the "Multi-AS" section of RFC4364. It depicts how each carrier may offer IP VPN services to multiple end customers and how multiple customers' traffic may traverse the same logical interface at the interconnection point between two carrier networks while being kept in separate VPNs.

Border Gateway Protocol with Multi Protocol extensions (MP-BGP) is used to exchange routes to customer addresses among PE routers that are attached to the same VPN, and also to associate an MPLS label with each VPN route distributed within an Autonomous System (AS). MP-BGP is also used to exchange this information between ASBRs.

In addition to "Multi-AS Option B", MPLS-ICI also supports "Option A," which defines Virtual Routing and Forwarding tables (VRFs) at each of the providers' ASBRs interconnected via a logical interface, so that each provider's ASBR looks like an end-user to the other's. Note that Option A requires an individual (logical) interface (e.g., an Ethernet VC, ATM/FR PVC or TDM timeslot) per VPN.

## LABELED IPv4 ROUTES

Sometimes carriers may wish to use the MPLS-ICI for not only MPLS-based services, but native IP services as well. To accomplish this for IP services, they can apply an MPLS label to the IPv4 traffic based on the route used to forward the traffic. If they are already running BGP on their ASBRs across the MPLS-ICI, it is beneficial to use this mechanism for distributing routes and labels across the interface. The benefit of distributing a label with an IPv4 route advertised by BGP is that it allows the establishment of LSPs to IPv4 destinations and distributes reachability information for IPv4 routes and other routes via a single protocol, namely BGP.

## PSEUDOWIRES

Today, many service providers sell Layer 1 (TDM) or Layer 2 (ATM, Frame Relay and Ethernet virtual circuits (VCs)) inter-carrier services provided over various types of legacy interconnections such as ATM NNIs. As carriers build out their IP/MPLS networks, they will continue to sell Layer 1 and Layer 2 services to their customers, but the transport of these services will be over a common IP/MPLS backbone. MPLS pseudowires can emulate TDM channels, as well as ATM, Frame Relay or Ethernet VCs, all over a common MPLS backbone, while still maintaining the desired characteristics and performance of each service. The MPLS-ICI will allow these services to be carried across a common MPLS-ICI link with the other services described here, thus allowing for migration away from the legacy interconnections.

Pseudowires may be single segment (the two edges of the network are defined as the ends of the pseudowire, and the pseudowire is transparent to the ASBR) or multi-segment, in which case segments must be associated with one another at the ASBRs to form an end-end connection. Multi-segment PWs are more complex when it comes to signaling their set-up and rerouting around failures. At the time of this writing, there is still some work to be done in developing mechanisms to provide for resiliency in the event of a failure on one of the pseudowire segments.

Whether using single segment or multi-segment pseudowires, the MPLS-ICI between two service provider networks can transport one or more emulated Layer 1 and 2 services.

In Figure 2, an MPLS pseudowire is shown to interconnect Customer 1 Site 1 and Customer 1 Site 2, extending Customer 1's L2/L1 connections over an IP/MPLS network. Another pseudowire is shown to interconnect Customer 2 Site 1 and Customer 2 Site 2, extending Customer 2's L2/L1 connections over the IP/MPLS networks.

— ATM/FR/Eth/TDM circuit  
 - - - ATM/FR/Eth/TDM Pseudowire

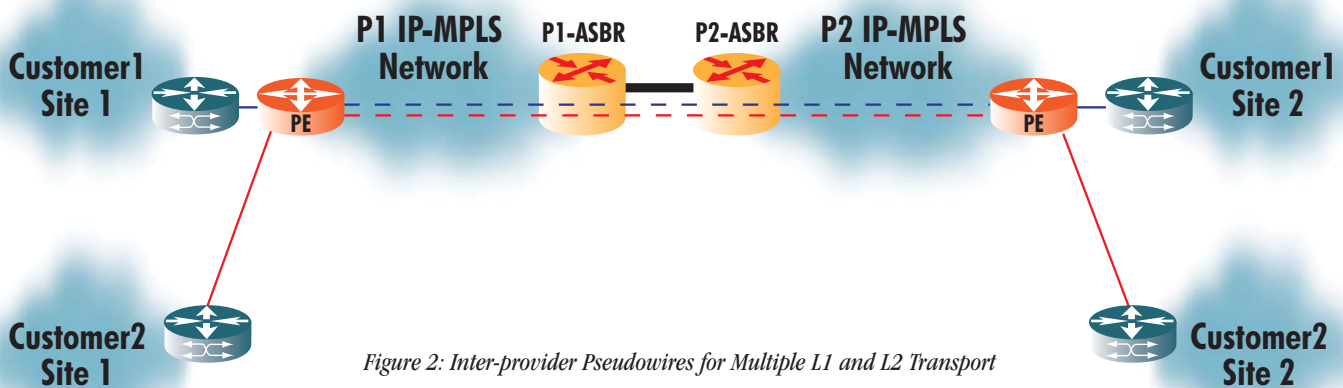


Figure 2: Inter-provider Pseudowires for Multiple L1 and L2 Transport

#### INTER-PROVIDER TE TUNNELS

TE tunnels have specific path, bandwidth requirements and QoS attributes associated with them and are typically used to carry specific delay- or loss-sensitive traffic (e.g., voice). They can be used to interconnect a router in one provider's network to a router in another provider network to give specific treatment to a particular type or types of traffic. Another use of TE tunnels is to enable one provider to tunnel through another provider's network in order to interconnect remote networks and extend required services to its customers on those networks.

In Figure 3, Provider 1 has 3 separate (island) networks, marked as P1.1, P1.2 and P1.3, and wishes to connect them via TE tunnels through Provider 2's IP-MPLS network.

A specialized example of the use of TE tunnels is the transport of Voice over IP services. While other types of LSPs may be used to carry voice traffic, TE tunnels may be ideal, with their bandwidth and QoS guarantees, to connect softswitches and Media gateways.

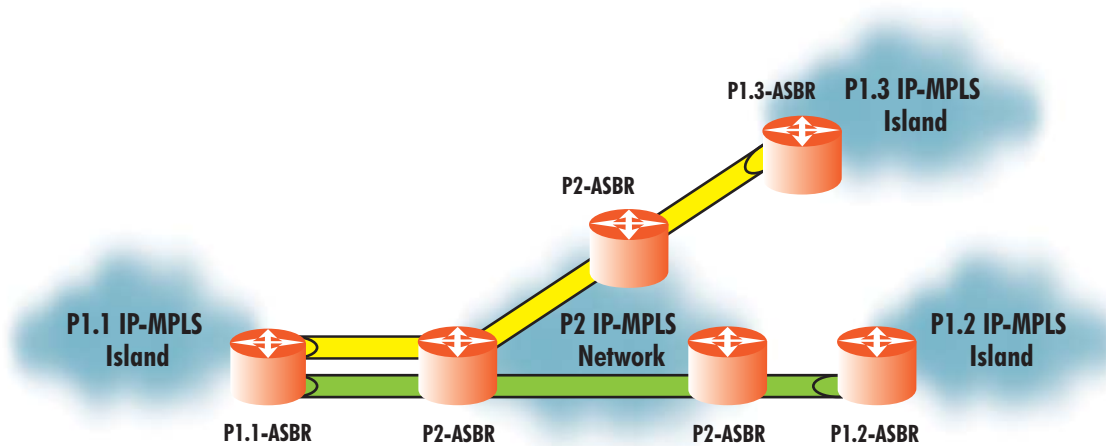


Figure 3: MPLS Tunnels as Data Trunks, Connecting Provider 1's Islands through Provider 2's Network

Each of these service applications provides a compelling need for a standardized MPLS interconnection between service provider domains. The case for the MPLS-ICI is even stronger, however, in that all of these services can share a single interconnection, thereby eliminating the need to have multiple technologies at the interconnection points, as service providers do today. This will vastly simplify management and reduce costs for service providers.

## MPLS-ICI ARCHITECTURAL OVERVIEW

The following are reference model diagrams that describe the architecture of the MPLS-ICI, illustrating the control protocols and service extensions across an inter-carrier MPLS interface. These reference models are applicable to all the MPLS-ICI applications and services discussed previously in this paper.

Figure 4 illustrates how BGP Routing and MPLS Signaling (e.g., BGP, LDP or RSVP-TE) are used to create LSP segments

that span the provider networks. These LSP segments may be tunnel LSP segments or service LSP segments (e.g., pseudowire segment or BGP/MPLS IP VPN LSP segment). The routing is broken into segments because the protocols used intra AS tend to share sensitive, link state details and topology information about the network that is not desirable to have shared with another provider. Similar issues exist for signaling.

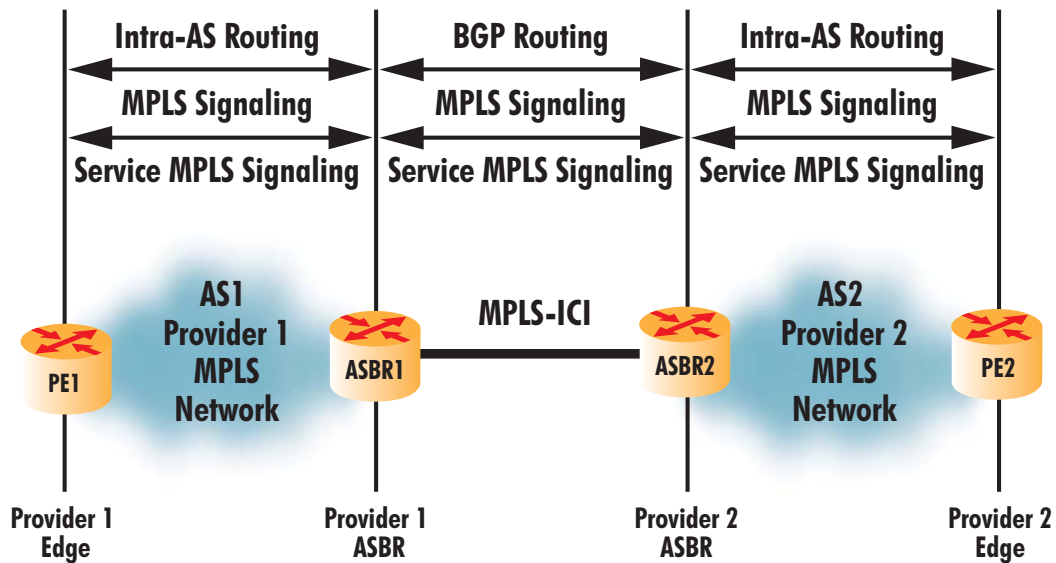


Figure 4: Control Protocols involved in extending MPLS services across an MPLS-ICI interconnecting two provider networks

Figure 5 illustrates how edge-to-edge MPLS services (e.g., Inter-AS BGP/MPLS IP VPN or L2 pseudowires) across two providers are composed of concatenated tunnel or service

LSP segments. A tunnel segment, if present, can carry multiple service LSP segments. LSP segments are established either via manual configuration or signaling.

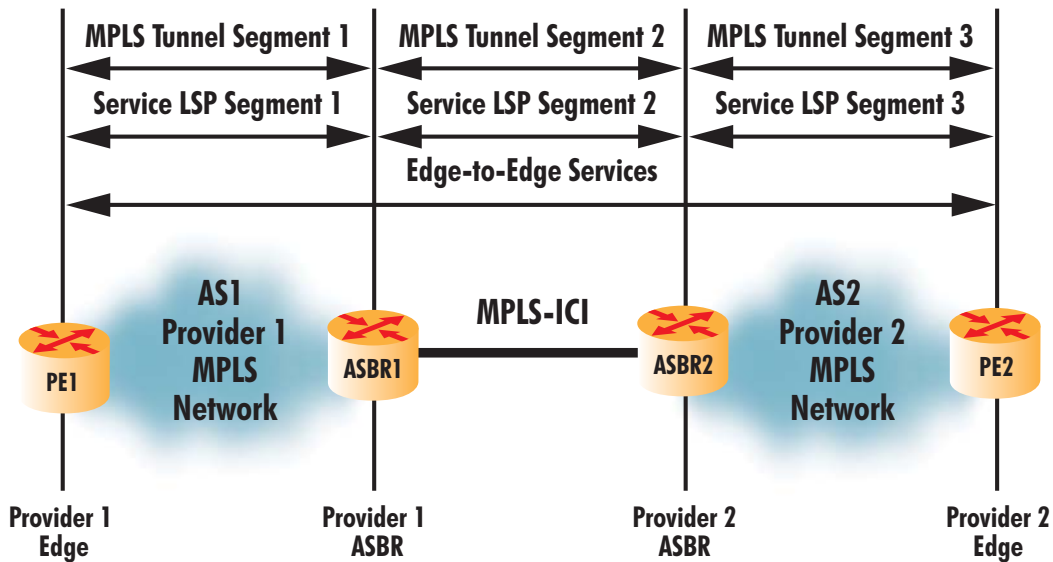


Figure 5: Services and LSPs extended across an MPLS-ICI

## CHALLENGES AND SOLUTIONS

While the MPLS-ICI specification will significantly simplify the interconnection process, the commercial arrangements may still remain complex. Standardization does not change the fact that all carriers are different and that there are many complicated operational challenges involved in an interconnection.

One such issue surrounds different classes of service. For example, one carrier may have three different classes of service but the partner network may have four. A multi-carrier network will need consistency if it is to effectively service a single enterprise customer. The MPLS-ICI specification includes an effective mapping mechanism that would allow two carriers to define a common subset of

QoS classes across their MPLS-ICI while maintaining individual QoS structures within their own networks.

Another issue that may have deterred carriers from establishing MPLS interconnections until now has been the concern for security. Some carriers may not wish to divulge their network topologies to other carriers, for example, for fear of disclosing proprietary information or rendering their network vulnerable to Denial of Service attacks. The MPLS-ICI Specification describes mechanisms that may be used to control disclosure of information, and defines varying levels of participation in carrier relationships so that an appropriate and effective agreement can be reached.

## SUMMARY AND CONCLUSIONS

---

MPLS-ICI capabilities are a vital element of carrier networks. As traditional communications services continue to experience considerable downward pricing pressures, it is vital that service providers are well positioned to cost-effectively deliver revenue-generating “next-generation” services, on a global level.

These services can only be delivered successfully with a full technical specification for MPLS-ICI that allows service providers to seamlessly connect their converged backbone networks. As demand by enterprise customers for global connectivity increases, the ability to provide seamless emerging services and to replicate traditional services over IP/MPLS will become paramount.

The IP/MPLS Forum’s MPLS-ICI Technical Specification provides a framework for early MPLS service applications. It is anticipated that later versions of the specification may include methods to dynamically reroute multi-segment pseudowires and other advanced OAM capabilities as these mature. It may also consider requirements for new services. The IP/MPLS Forum is committed to advancing MPLS-ICI to enable the deployment of global MPLS services as well as future services as they emerge.

**For more information, please contact the IP/MPLS Forum at [www.ipmplsforum.org](http://www.ipmplsforum.org) or at [info@ipmplsforum.org](mailto:info@ipmplsforum.org).**



48377 Fremont Blvd., Suite 117  
Fremont, CA 94538  
Phone: +1-510-492-4056  
Fax: +1-510-492-4001  
E-mail: [info@ipmplsforum.org](mailto:info@ipmplsforum.org)