

Addressing Inter Provider Connections With MPLS-ICI



Introduction

Why migrate to packet switched MPLS?

- 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 by developing a converged network.
 - Fewer networks to manage means less operation support requirements
 - In addition, MPLS core networks enable the delivery of new network services and will support new multi-media content with QoS requirements
 - 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

Overview

Presentation goals

- This presentation -
 - 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.

How does interconnect happen today?

- This is currently achieved only via bilateral agreements and is limited to basic IP interconnect
- Limitations?
 - These agreements are limited to:
 - Basic IP interconnect OR
 - NNIs for the transport of native layer 2 services such as ATM and Frame Relay OR
 - Ethernet NNIs OR
 - MPLS inter-connects using proprietary bilateral agreements
- The former IP/MPLS Forum, (now united with the Broadband Forum) developed a specification that addresses the full spectrum of interconnect issues.
- Why?
 - 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,
- This specification includes 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)
 - Packet forwarding and security requirements

MPLS Inter-Carrier Interconnection (MPLS-ICI)

- The resulting MPLS Inter-Carrier Interconnection (MPLS-ICI) Technical Specification is a vital tool
 - Reduces service providers' costs
 - Adds 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)
 - 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.

Market Trends



Market Trends

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

Market Trends

New Innovative Services over MPLS

- 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.

Market Trends

Large Multinational Corporate Customers

- There is a growing communications needs and wide geographic spread of large multinational enterprises
 - Which means service providers are 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.
 - 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.

Applications

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.

Why interconnect?

- 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 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.

Big Picture

What does MPLS-ICI Accomplish?

- 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.

What does it address?

- 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.

Inter-Autonomous System (AS) Border Gateway Protocol (BGP)/MPLS IP VPNs

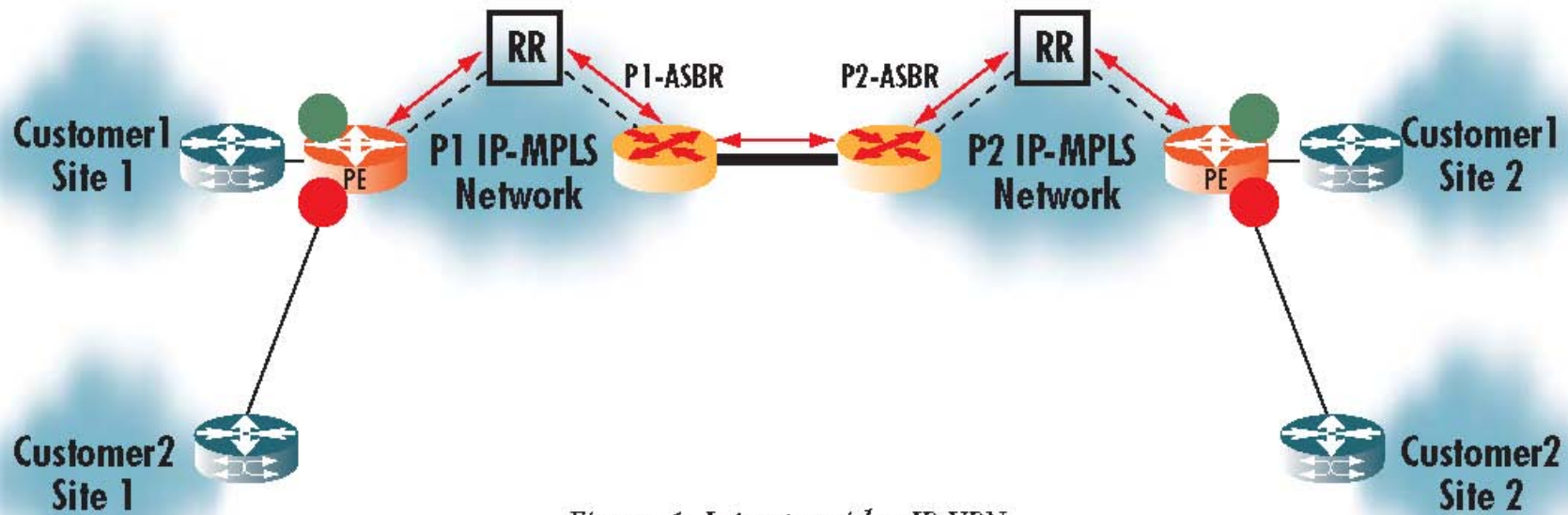


Figure 1: Inter-provider IP VPN

Inter-Autonomous System (AS) Border Gateway Protocol (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.
- The previous diagram illustrates one method by which two Service Providers exchange enterprise customer routes between Autonomous System Border Routers (ASBRs) in order to provide 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?
 - This allows the establishment of LSPs to IPv4 destinations and distributes reachability information for IPv4 routes and other routes via a single protocol, namely BGP.

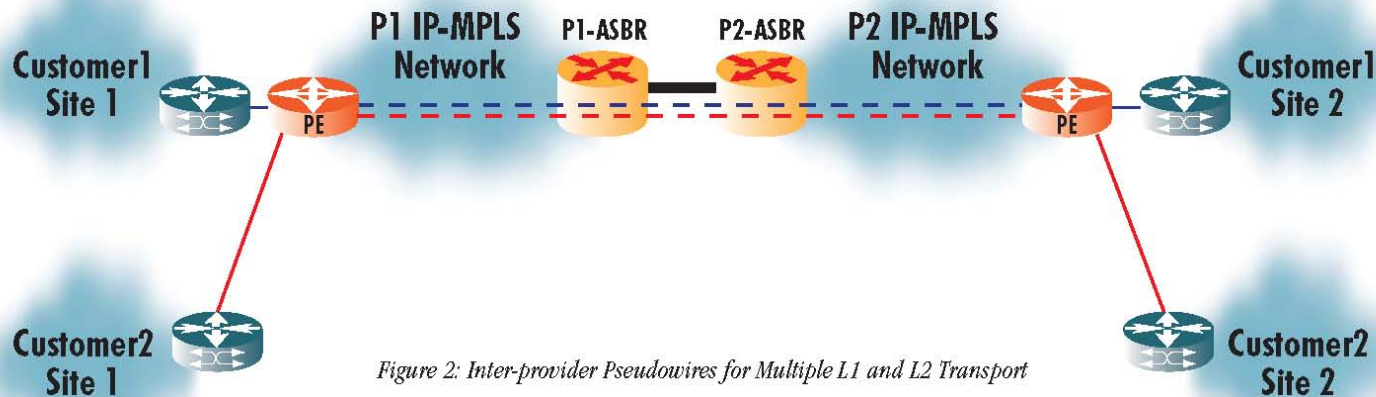
Pseudowires

- 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 back-bone, 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.

What are pseudowires?

- Pseudowires (PW) 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.

Pseudowire example

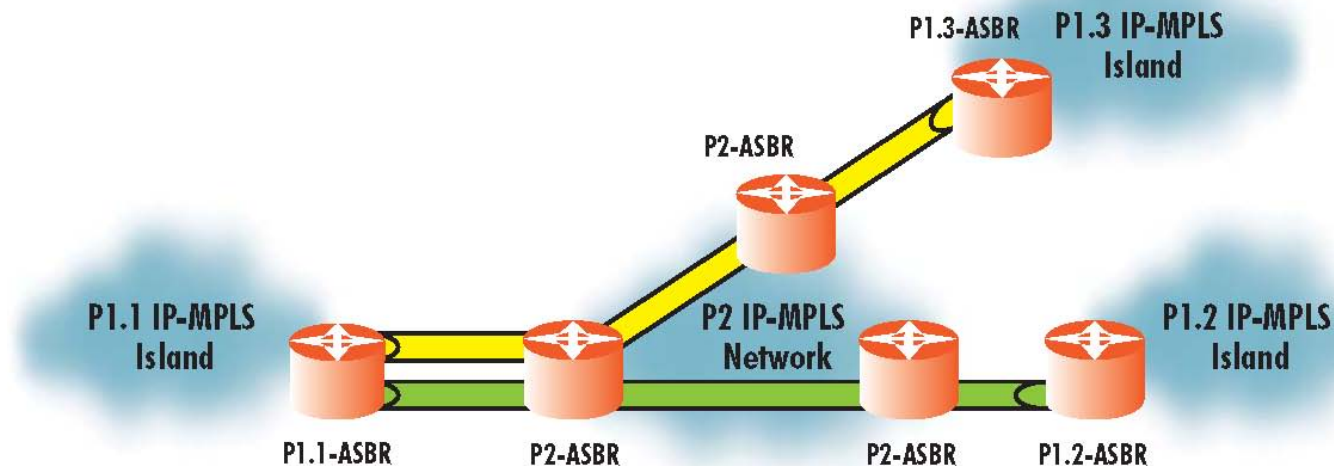


- In Figure 2, an MPLS pseudowire is shown to interconnect Customer 1 Site 1 and Customer 1 Site 2, extending Customer 1's L2/L1 connections over an IP/MPLS network.
- Another pseudowire is shown to interconnect Customer 2 Site 1 and Customer 2 Site 2, extending Customer 2's L2/L1 connections over the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

Inter-Provider TE Tunnels

- TE tunnels have specific path, bandwidth requirements and QoS attributes associated with them
- TE tunnels are typically used to carry specific delay- or loss-sensitive traffic (e.g., voice).
- How are they used?
 - 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.
 - 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.

TE Tunnel Example



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

- 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.

Applications in Summary

- 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.

Reference Models

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



Architectural Overview

Control protocols

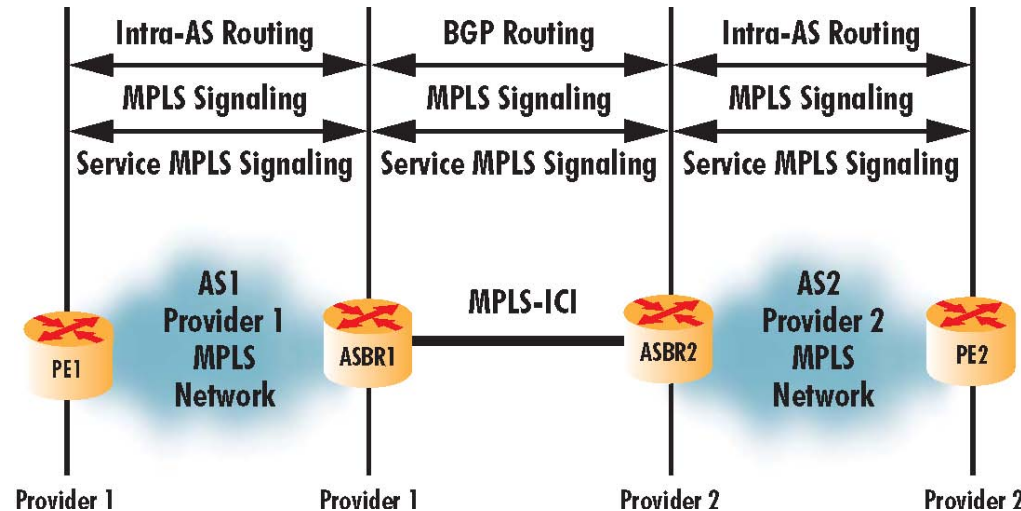


Figure 4: Control Protocols involved in extending MPLS services across an MPLS-ICI interconnecting two provider networks

- 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.

Services & LSPs extended across MPLS-ICI

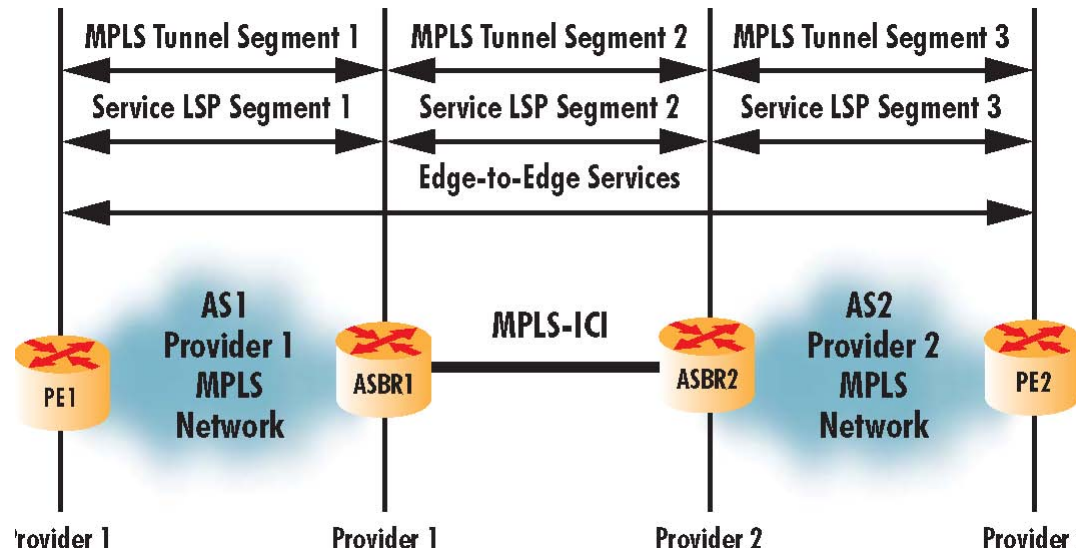
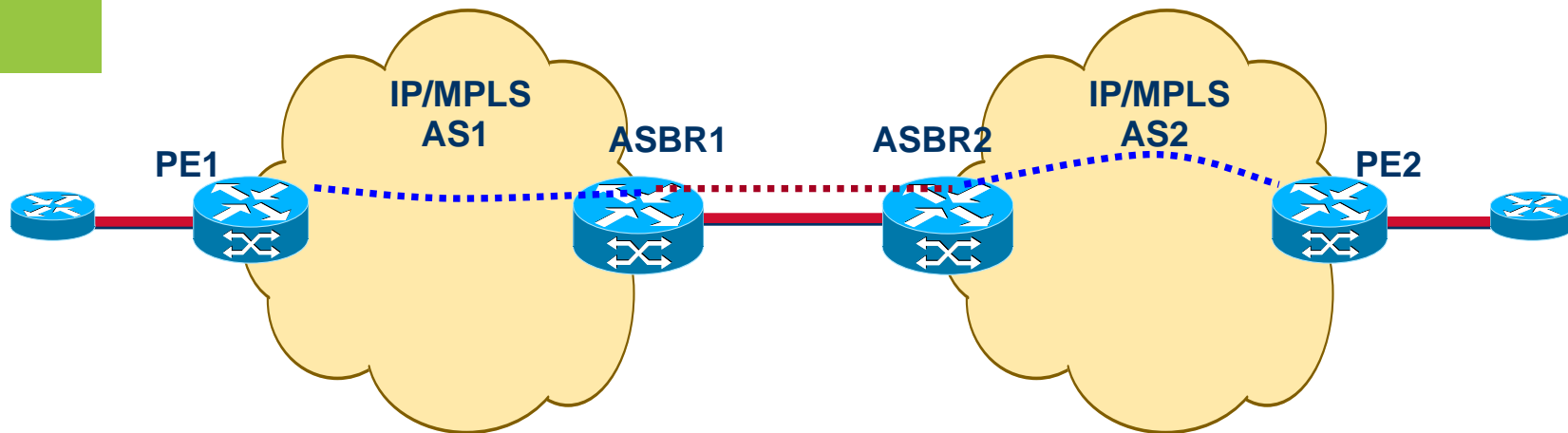


Figure 5: Services and LSPs extended across an MPLS-ICI

- Figure 5 illustrates how edge-to-edge MPLS services LSP segments.
- A tunnel segment, if present, can carry multiple (e.g., Inter-AS BGP/MPLS IP VPN or L2 pseudowires) across service LSP segments.
- LSP segments are established either via two providers or composed of concatenated tunnel or service manual configuration or signaling.

LSP Setup at ICI



- Three mechanisms of LSP establishment across a provider domain boundary are defined:
 - All-static configuration
 - Statically configured and signalled establishment
 - Dynamic establishment
- Satisfy various interconnect models that fit providers' policies on security, information sharing and setup control
- May help the timely development of solutions
 - e.g., Static configuration may involve the least amount of development and have the least amount of interoperability issues
- Different scenarios for InterCarrier LSP setup are applications dependent

Challenges & Solutions

- While the MPLS-ICI specification will significantly simplify the interconnection process, 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.
- Issues?
 - Different classes of service
 - 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.
 - Concern for security
 - Some carriers may not wish to divulge their network topologies to other carriers, 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.

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.
- 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 **MPLS-ICI Technical Specification** provides a framework for early MPLS service applications.
- Next steps?
 - 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 Broadband Forum is committed to advancing MPLS-ICI to enable the deployment of global MPLS services as well as future services as they emerge.

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specifications at**

<http://www.broadband-forum.org/technical/ipmplstechspec.php>

