MultiProtocol Label Switching Applications for Broadband Services

Broadband network operators are increasingly looking to enhance revenues and profits by offering an expanded bundle of services to both residential and business customers. For residential users, broadband network operators are looking to Voice over IP (VoIP), tiered data services and support for multiple service providers to grow their revenue streams in Open Access environments. Open Access today is focused on offering a choice of Internet Service Providers (ISPs) but in the future this could also include telephony providers as well.

For both corporate and government customers, broadband network operators are looking to capture business from incumbent telephony providers by offering secure, highly available and deterministic service over the Hybrid Fiber Coax (HFC) network, at a more competitive price.

First-generation Cable Modem Termination System (CMTS) platforms lack the necessary power and flexibility and many next-generation CMTS platforms do not have the carrier-class routing capabilities required to support these exciting new services. Next-generation CMTS solutions with integrated intelligent edge routing capabilities offer the hardware and software platforms necessary to allow operators to achieve their goal to increase revenue while at the same time simplifying the operation of the cable data network.

Broadband network operators are increasingly looking to enhance revenues and profits by offering an expanded bundle of services to both residential and business customers.

The Motorola Broadband Services Router 64000 (BSR 64000) is an intelligent CMTS/edge router that provides rich support for sophisticated protocols. It has hardware-based filtering and forwarding and is a next-generation platform that allows broadband network operators to offer residential, business and government customers enhanced services that command premium pricing. One of the most significant protocol enhancements that will enable broadband network operators to achieve their aggressive revenue targets through additional services is MultiProtocol Label Switching (MPLS).

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Applications

Business/Customer Applications

The MPLS standard allows broadband network operators to create a myriad of new revenue-generating services so they can move beyond "best-effort" broadband Internet access and offer high-value services with premium pricing. Cable providers are challenged by competing technologies such as DSL and need to offer better business services to retain existing customers and capture new enterprise network accounts.

Business Services

Broadband network operators can capture new revenue streams from incumbent carriers by offering suites of business services. For example, companies that need to connect different branch offices and also run business-sensitive applications over a secure network will benefit from the convenience of a high-quality cable connection, as well as from the security and user mobility offered by MPLS Virtual Private Networks (VPNs) that allow users to securely connect private networks through the Internet. This approach will drastically reduce monthly private line communication costs and entice new business subscribers to the cable network.

Instead of provisioning expensive leased lines, Frame Relay or even ATM connections, business users can connect simply over the HFC network and establish secure, encrypted connections with guaranteed service levels. There are many other possibilities for business services as well. For example, the steadily increasing number of remote workers can leverage the cable access network to improve productivity. Telecommuters can gain high speed access to enterprise network resources, and Small Office/Home Office (SOHO) workers can establish secure VPN connections with their customers.

Triple Play

Broadband network operators need to offer "Triple Play" services — data, voice and video — over the HFC network so they can create lasting, long-term relationships with business subscribers. With both primary line and secondary line voice services deployed by cable operators worldwide, MSOs will have the ability to deploy a "One Stop Shopping" approach for multiple services (see VoIP Solutions brochure at http://www.motorola.com/broadband/ipns_datasheets.html). They will complement high speed data services with VoIP and digital video, and in the future, they will add support for streaming video services.

Broadband network operators can capture new revenue streams from incumbent carriers by offering suites of business services.

Tiered Data Services

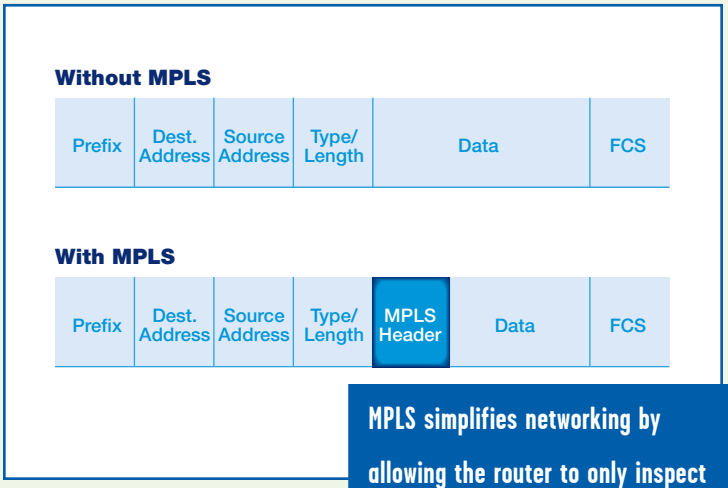
Tiered data services allow broadband network operators to offer flexible services to target market segments. MSOs need to effectively deliver different tiers of services with varying QoS levels and pricing schemes — such as Gold, Silver and Bronze services — so subscribers can select the level of services for which they are willing to pay. The successful delivery of tiered data services requires the ability to ensure end-to-end QoS so that customers paying premium prices receive premium services. Operators also need the flexibility to implement bandwidth limits to ensure that services do not receive more than their committed bandwidth levels. This will allow operators to successfully manage expectations and maximize return-on-investment in network infrastructure by encouraging subscribers to select more premium service offerings.

Multiple Service Provider Support

Operators can create wholesale revenue streams by allowing customers to select from multiple providers of service, content and applications over the HFC access network. This requires the ability to isolate and police individual traffic flows to ensure compliance with Service Level Agreements (SLAs) by provider, subscriber and application.

MPLS: A Technology Primer for Cable Executives

MPLS is an industry-standard approach developed to reduce the forwarding complexity in a network. MPLS combines the simple and fast-forwarding characteristics of Layer 2 switching with the flexibility and scalability of Layer 3 routing. These layers correspond with the OSI model.

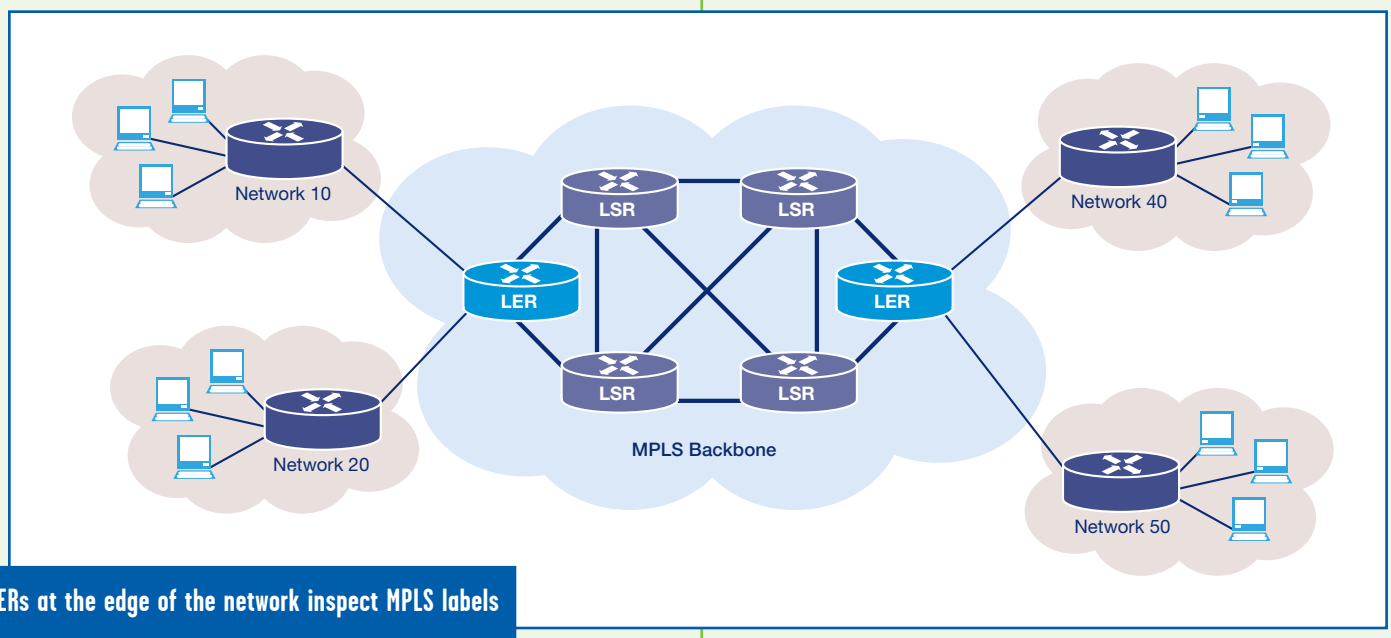


MPLS simplifies networking by allowing the router to only inspect the MPLS header

As a packet travels from a source to a destination in a standard non-MPLS routed network, an independent forwarding decision must be made at each router along the path. As it travels through the network, each router analyzes the packet and determines the "next hop router" where the packet must be sent to arrive at its final destination. With the high-speed network links and the large volumes of traffic today, packet inspection can be very burdensome for each router and it becomes difficult to implement advanced features, such as supplying varying levels of QoS for different users or for different applications.

However, with MPLS a packet only has to be analyzed once — when it enters the network. As the packet is received at the first router in the network, the router assigns a short "label" to the packet. When the packet is forwarded to the next router, the label is included in the packet. At subsequent routers there is no further analysis of the packet's Layer 3 address. Instead, the label is used to instruct the router how to forward the packet. The label is not only used to make packet forwarding decisions, but it may also contain information about the required QoS of the packet (i.e. priority, minimum bandwidth required, etc.).

MultiProtocol Label Switching



LERs at the edge of the network inspect MPLS labels once and efficiently route them through the switched core to the target destination

Basic MPLS Concepts

An MPLS network is made up of Label Edge Routers (LERs) and Label Switch Routers (LSRs). The LERs are responsible for classifying each packet based on some user-configurable policy (source, destination, port, QoS class, etc.) and assigning a label to the packet.

The LSRs are responsible for forwarding the packet along the correct Label Switched Path (LSP) based upon the label. In order for a packet to properly travel across the network, all routers in the path must be aware of the label and the assigned LSP. The LSPs can be set up statically at each router along the path or dynamically via such signaling protocols as Resource Reservation Protocol with Traffic Engineering extensions (RSVP-TE) and the Label Distribution Protocol (LDP).

The MPLS labels are fixed in length. This approach simplifies and accelerates the forwarding decisions in the core, especially if the label processing is performed in hardware. This process is called “Label Switching.” The labels only have local significance to the switch/routers that are forwarding the MPLS packets and are used to identify packets that are in the same group and equivalence class.

Labels are added (“pushed”) in the ingress edge of the network, “swapped” at intermediate LSRs and removed (“popped”) at the egress edge of the network. The path defined from the point of origin to the destination is the LSP and it is unidirectional in nature.

Benefits of MPLS

Because LSPs are established end-to-end across the network, they can be used as "tunnels" for all packets that need to travel to the same destination. This makes it possible to provide advanced services. For example, operators can offer VPN services by using LSPs to connect two disparate networks, thus making them look like a single, larger network. Operators can support Open Access by using different LSPs to tunnel traffic to different service providers, and they can deliver tiered data services with varying levels of QoS by establishing different LSPs for different packets requiring different service levels. The key benefits of MPLS include the following:

Simple Forwarding Scheme

By having a defined label length, the packet forwarding decision is made based on an "exact match" as opposed to the "longest match" approach employed by the traditional routing approach. When this simple scheme is implemented in hardware it allows for a much faster forwarding mechanism than possible with traditional Layer 3 routing.

Traffic Engineering

Operators can use Traffic Engineering techniques to optimize network performance. The main objective of Traffic Engineering is to optimize the use of network resources to support transport of the services offered, depending on a set of conditions that may vary from time to time. A major advantage of MPLS is that LSPs can take routes different than those determined by the underlying routing protocols (such as OSPF, BGP or IS-IS).

QoS

When encapsulating multiple packets with a common Forwarding Equivalence Class (FEC) within an LSP, the QoS is set at the origin of the LSP. This is much better than the per-hop nature of other QoS mechanisms such as Differentiated Services (DiffServ) that require the QoS to be evaluated at each router or "hop" within the backbone. Combining the appropriate QoS setting with Traffic Engineering techniques will ensure that the defined path for each packet is correct.

Intelligence at the Network Edge

Because the work of classifying packets by their FEC into a certain LSP is done at the edge of the network and not on a hop-by-hop basis, broadband network operators can deploy intelligence at the network edge to streamline packet processing and more efficiently utilize network assets. The packet classification and policy-based routing decisions are made at the edge LER. This is one of the key reasons why hardware-based packet classification and filtering are critical. This work at the edge relieves the backbone LSRs from being overloaded, allowing much faster and more efficient packet forwarding through the IP backbone network. At the same time, the MSO can retain full control of the classification rules, especially when implementing Open Access.

Operators can use Traffic Engineering techniques to optimize network performance.

Scalability

Due to its simpler forwarding mechanism, MPLS is much more scalable than Layer 3 routing.

Support for Multiple Transport Protocols and Media

Because MPLS is a Layer 2-independent protocol, a packet can traverse through different protocols (such as ATM, Frame Relay, PPP and HDLC) as well as different media (Ethernet, Packet over SONET, etc).

VPN Overview

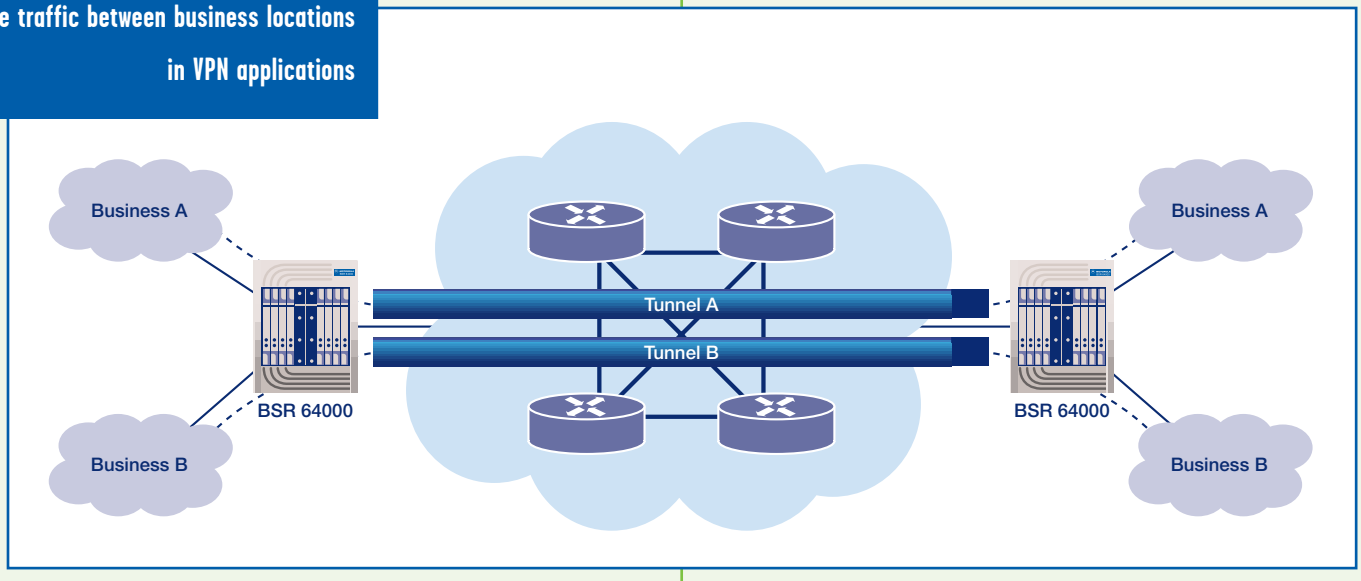
MPLS VPN Overview

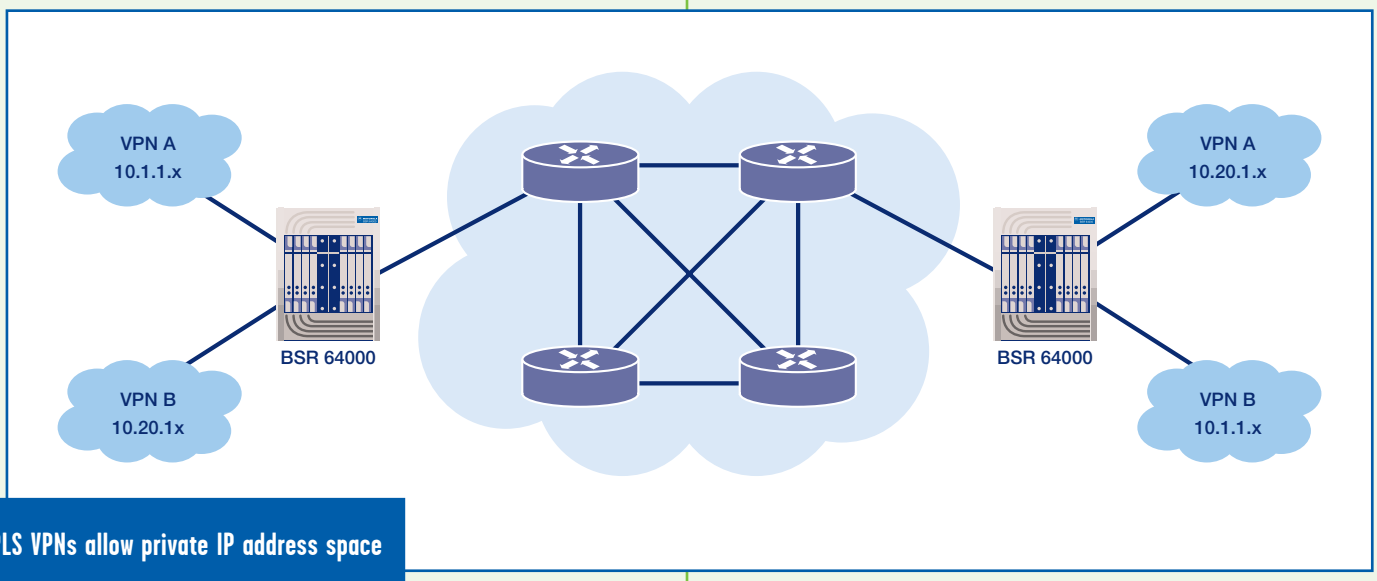
A VPN is a private network deployed over a shared or public network. Broadband network operators can allow enterprise network customers to drastically reduce private line bandwidth charges by allowing them to create secure VPNs over the Internet. They can architect VPN solutions that maintain the characteristics of the WAN VPN architecture used today — including security, network management and QoS — at a fraction of the cost.

For initial VPN implementations, phone companies allowed enterprise customers to connect different sites over secure connections that isolated the VPN connections from other users sharing the same public network infrastructure. This solution continues to work well, but it becomes extremely complicated to configure and manage as the network grows. It provides major scalability problems and it can be extremely costly to provision the necessary bandwidth to support QoS requirements over the PSTN.

Now, broadband operators can allow enterprise customers to build much more scalable and cost-effective VPNs using MPLS to create secure, end-to-end encrypted tunnels from the enterprise location through the HFC access network and through the Internet to other enterprise locations.

MPLS tunnels are created to carry secure traffic between business locations in VPN applications





BGP MPLS VPNs allow private IP address space to be used across the public backbone

The number of VPN users will continue to grow as companies expand their communication over shared networks. Cable operators can offer a compelling value proposition by delivering a more economical alternative for business networks than expensive circuit switching/ packet switching networks, such as those based on leased lines, or on Frame Relay or ATM backbones.

The VPN capabilities of MPLS allow broadband network operators to provide private services over a shared infrastructure. The main advantage of this approach is the reduced cost compared to traditional approaches based on leased lines, Frame Relay or ATM. Cable operators can not only deliver broadband services more cost effectively, they can also provide greater support for scalability requirements and deliver the same levels of security, manageability and flexibility. There are two primary standards-based approaches to supporting MPLS VPNs over cable networks:

BGP MPLS VPNs

A key advantage to Border Gateway Protocol (BGP) MPLS VPNs (RFC 2547) is that they allow private IP address space to be used across the public backbone.

To provide VPN services in an effective manner, the VPN solution needs to support private address spaces. Operators need to be able to provide traffic isolation among different VPNs to ensure security and also ensure that one VPN does not impact another over the shared media network.

Prior to BGP MPLS VPNs, private IP addresses were restricted from entering the Internet because they were not routable. Customers were forced to use Network Address Translation (NAT) or some other method to connect their private backbones to the public Internet. The BGP MPLS VPN specification includes a new addressing scheme — "VPN-IPv4 Address Family" — that allows the use of private IP addresses across the public backbone. This new address is a combination of the original IP address and a "Route Distinguisher."

Because a different Route Distinguisher is used for each VPN that the router is attached to, the same IP address or IP subnet can exist in more than one place on the network — as long it does not exist in two places within a single VPN. This approach to MPLS VPNs uses the BGP protocol to propagate the routes necessary to create VPN services and keep the routing tables separated one from another. The diagram on page seven demonstrates an example of a BGP MPLS VPN scenario.

MARTINI DRAFT MPLS VPNs

A set of draft IETF documents known as the Martini drafts has won support from both providers and equipment manufacturers. This approach provides an alternative to BGP VPNs by allowing broadband network operators to offer Layer 2 MPLS VPNs. They can use diverse non-IP protocols across IP access networks and the Internet. Broadband network operators can therefore support native protocols such as ATM, Frame Relay and Ethernet across HFC access networks.

Typically Layer 2 MPLS VPNs are invisible to the end user, much in the same way the underlying ATM infrastructure is invisible to Frame Relay users. The customer is still buying Frame Relay or ATM services regardless of how the provider provisions the service over the HFC network. By using MPLS Labels, a broadband network operator can create closed paths that are isolated from other traffic within the HFC network, providing the same level of security as other Permanent Virtual Circuit (PVC)-style services such as Frame Relay or ATM.

This approach provides a simple migration path for enterprise customers because they can migrate their VPNs from the public network to the Internet using the same network protocols. Broadband network operators can even leverage the transparent connectivity of MPLS Layer 2 VPNs to offer advanced business services, such as off-site storage and disaster recovery.

Summary

MPLS VPN Advantages Summary

- Broadband network operators can overcome IP addressing problems by allowing the applications or systems on the end of the tunnels to use any IP address they want, allowing overlapping of IP addresses. This represents a big advantage for MSOs because they will not need to worry about managing customer IP addresses.
- MPLS tunnels are the most efficient tunneling technology compared to the others existing today (like IP-in-IP tunneling, GRE, IPSEC and others). In addition, MPLS tunnels can be established more easily than other tunneling approaches.

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- The use of MPLS tunnels drastically improves the network utilization if Traffic Engineering is used. This represents a significant advantage to MSOs because they can build larger networks without the associated problems inherent to large, purely routed networks.
- In BGP applications, even when MPLS is intended to support multiple transport protocols the "transported" protocol is mainly Internet Protocol (IP). Even though MPLS now only supports IPv4, the technology is flexible enough to add support for IP version 6 (IPv6).
- Cable providers can deploy Martini draft Layer 2 VPNs to easily migrate PSTN VPNs using non-IP protocols to establish secure tunnels.

Sample Applications

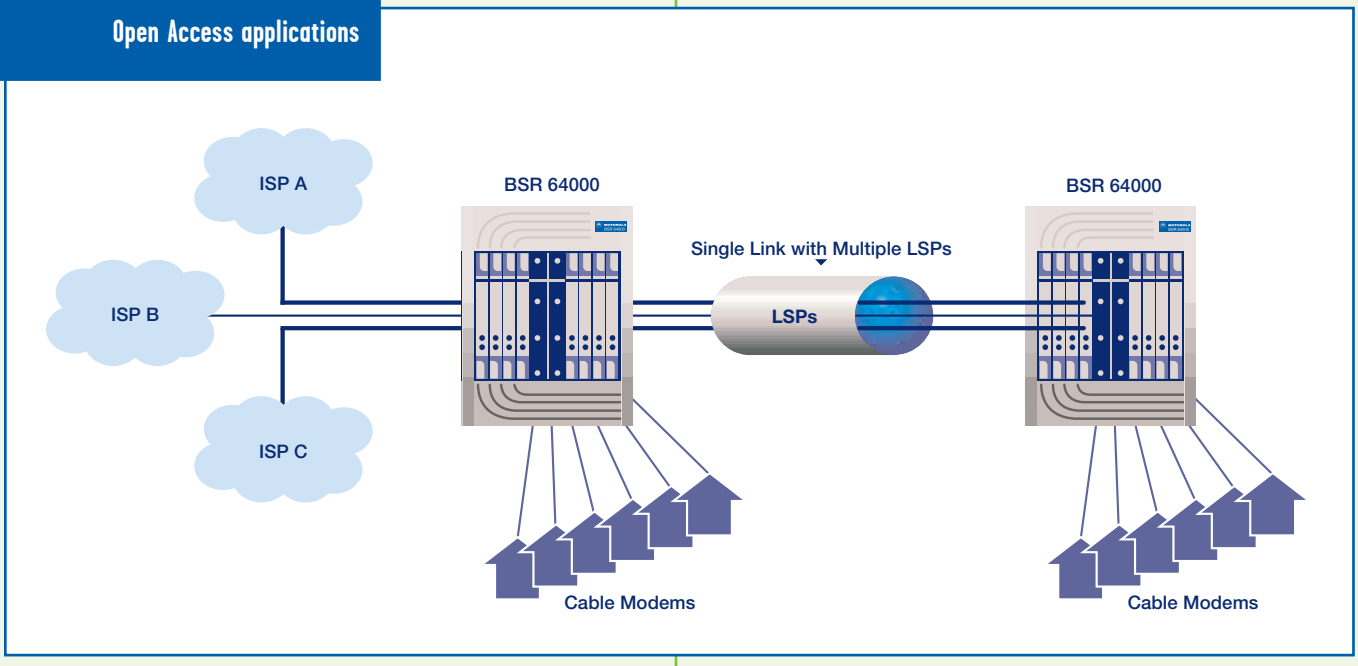
MPLS VPN Sample Applications

The following are several representative MPLS VPN applications that broadband network operators can deploy for enterprise customers:

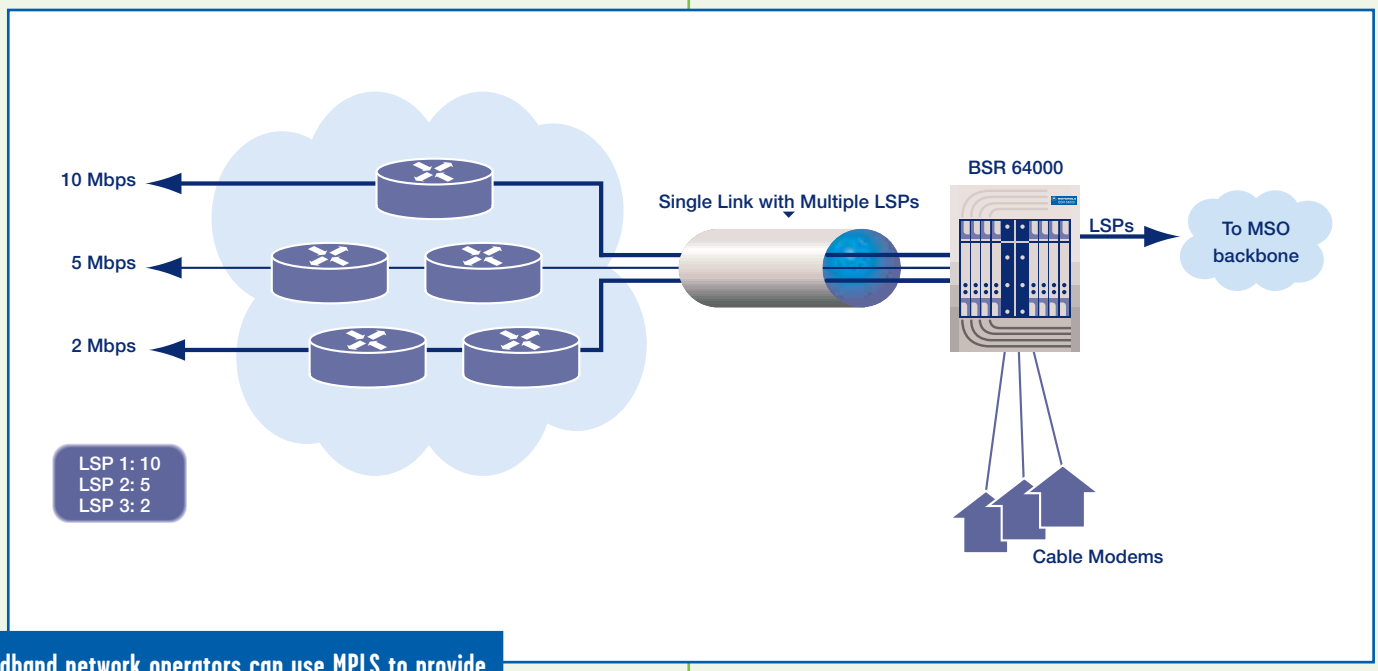
Traffic Isolation in Open Access Environments

MPLS can be used to logically separate traffic that is destined for different service provider partners so MSOs can develop wholesale revenue streams by supporting Open Access. In this scenario, the enterprise customer could be presented with a choice of ISPs at the time of sign-up. Each service provider on the shared HFC network would be assigned an MPLS label, and customer traffic would be securely routed over an LSP to the intended provider. A typical Open Access scenario is illustrated below.

Broadband network operators can use MPLS to support multiple ISPs in Open Access applications



MultiProtocol Label Switching



Broadband network operators can use MPLS to provide multiple levels of service with end-to-end QoS

Private IP Space

The use of private IP addresses assigned to business and government users — regardless of location — has always been a challenge for network service providers. This is especially true for broadband network operators that typically control all Customer Premises Equipment (CPE) IP addresses. BGP MPLS VPNs allow broadband network operators to provide services to users that do not have an explicit IP address issued by the MSO. Using MPLS VPNs, these "private" addresses can now be hidden and routed through the HFC access network without concern.

Traffic Engineering

It is important to note that Traffic Engineering may use network paths different than those established by routing protocols such as OSPF, Exterior BGP or Interior BGP. Chances are that the paths selected by routing protocols will be the most congested ones, but Traffic Engineering realizes this and routes VPN flows through alternative paths.

For example, minimizing packet loss or jitter in the network is key for time-sensitive services such as packetized VoIP. Operators also need to overcome congestion. Traffic Engineering factors in all the variables that affect the overall network status. It then tries to arrive at the best ratio of scalability and robustness of the network while maintaining the QoS levels required by enterprise customers.

Conclusion

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Now more than ever, broadband network operators are looking to increase revenues by expanding services to both residential and business customers. The Motorola BSR 64000 is a carrier-class MPLS edge router architected for hardware-based packet filtering and forwarding. It provides the performance and flexibility needed to support MPLS across multiple networks.

The BSR 64000 can serve as an MPLS LER that inspects traffic flows in hardware to enable real-time flow classification and forwarding at the edge of the network. It can also be configured as an LSR within the backbone of the broadband operator's network because of its advanced routing capabilities and performance. A carrier-class implementation of MPLS allows operators to create LSPs from the edge of the network through the core network of multiple providers. Broadband network operators can achieve their increased revenue goals while at the same time simplifying the operation of their cable data network.

Motorola offers extensive experience in providing high-speed data solutions for the broadband industry. Motorola is uniquely qualified to provide broadband network operators with a truly Triple Play, end-to-end solution encompassing the entire data network — from the cable modem to the Internet backbone — thus enabling voice, video and data services as well as support for advanced business services including VPNs. *For more information about the Motorola BSR 64000, please visit* *http://www.motorola.com/broadband/ipns_bsr64000.html.*

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