

# OPTIMIZING MEDIA-RICH CONTENT DELIVERY WITH POINT-TO-MULTIPOINT LABEL SWITCHED PATHS

---

## Table of Contents

Executive Summary .....	1
Introduction .....	1
Common Expectations, Services, and Requirements .....	1
Optimized Content Delivery .....	1
Convergence Time and Resiliency .....	2
Performance .....	2
Streamlined, Integrated Operations .....	2
Limitations of PIM-Based Delivery Model .....	2
Challenges of PIM-Based Service Rollouts .....	2
Lack of Control over Multicast and Unicast Traffic .....	3
Optimizing Multicast-Based Rollouts with High-Performance P2MP LSPs .....	4
Conclusion .....	5
References .....	6
About Juniper Networks .....	6

## Table of Figures

Figure 1: Comparison of MVPN with PIM versus P2MP LSP as a delivery mechanism .....	3
Figure 2: Content distribution with point-to-point LSPs .....	4
Figure 3: Economical content delivery with P2MP LSP .....	5

## Executive Summary

Optimized content delivery has become a critical requirement due to the increased level of media-rich traffic on networks. This document describes how content delivery and broadcast services are challenging networks and explains how emerging technologies such as point-to-multipoint (P2MP) label switched paths (LSPs) help resolve them.

## Introduction

Telecommunications companies, cable providers, large financial enterprises, and content service providers seek to offer services that enable them to increase profitability while developing their brand equity through a premium user experience. Emerging media-rich services are posing new technological challenges in terms of optimized content insertion, transformation, and distribution. Service providers, content providers, and cable operators are expanding their high-definition (HD) offerings to thousands of channels, while offering increasingly sophisticated media-rich collaboration tools.

Multiple service operators (MSOs), for example, are introducing managed services for medium-sized and small-office and home-office (SOHO) businesses, including video conferencing and enterprise triple-play bundles. These offerings combine either Layer 2 or Layer 3 VPN services with optimized content delivery mechanisms. Similar proven mechanisms are leveraged by globally managed service providers that also offer service delivery and content distribution infrastructures spanning metro, national, and worldwide areas. Services typically include content delivery, caching, and media-rich collaboration tools such as news broadcasts and transactional services.

These offerings raise scaling and operational challenges across multiple dimensions. They also require a mechanism complementary to VPNs to deliver multi-media content securely, with resiliency, and with maximum cost effectiveness, all while ensuring a flawless quality of experience. Juniper Networks® offers a P2MP LSP solution that addresses the full set of requirements to meet the demands of these emerging applications.

## Common Expectations, Services, and Requirements

As the number and types of services that providers are offering increases, the expectations and requirements for the network are also being redefined. Uncompromised performance, optimized cost structures, carrier-class reliability with low latency, and superior quality of service (QoS) are becoming critical infrastructure requirements.

### Optimized Content Delivery

Traditionally, multicast technology options for content delivery were limited, and implementations were based on IP Protocol Independent Multicast (PIM) protocols in the infrastructure core. Early PIM-based multicast deployments posed a series of challenges for network operators.

- **Traffic engineering (TE) and path control across the infrastructure.** IP multicast does not allow end-to-end TE paths and guaranteed QoS. It is difficult to determine the actual path IP multicast traffic takes and its effects on link and node failure events. A multicast VPN (MVPN) with P2MP-based technology provides a solution to this issue. It also resolves some of the challenges involved in supporting both PIM and MPLS topologies by removing the need for PIM in the core and by simplifying deployment, maintenance, and troubleshooting. P2MP offers flexibility in setting up statically and dynamically routed redundant paths to multiple branch LSPs.
- **Quality of service.** Most current MPLS networks use only a small percent of the available bandwidth and are allowed a maximum of 50 percent of the available utilization. For broadcast services, this low link utilization is not cost effective. A real class of service with the capability to control network traffic by service and by customer becomes a critical need when broadcast, multicast, and unicast services are offered on a convergent network. Advanced managed enterprise services, such as RFC 2547bis-based VPNs, Layer 2 VPNs, pseudowires, and virtual private LAN service (VPLS) require an MPLS framework for service delivery.
- **Security and traffic separation.** Financial services, news services, and stock exchanges require secure, high-touch content with very low latency and nonstop operation. Financial applications need segregation of multicast traffic for different customers to protect security. For example, a multicast receiver can send a multicast join request for any service; therefore compartmentalization mechanisms are required for restricting access. Although IP multicast can achieve the broadcast requirement, it lacks the security that is offered by combining MVPN services and the P2MP delivery mechanism.

## **Convergence, Time and Resiliency**

Superior convergence with protection against link, node, and path failures is essential for mission-critical applications. As well, a high level of resiliency is needed to support real-time applications and keep customers satisfied; these applications typically require convergence times below 50 milliseconds. For example, any traffic loss for a video broadcast is unacceptable because it adversely affects the quality of the customer's experience. Loss of an I-frame in a Moving Picture Experts Group (MPEG) stream can cause visible degradation of video quality, in contrast to loss of a data frame in a TCP stream. The quality of experience for a video delivered over a packet network is measured based on the delay factor and the media loss rate (media delivery index). Loss of a frame on a Session Initiation Protocol (SIP) voice stream can also affect voice quality. Circuit emulators (for example, in a mobile solution) over packet networks also require aggressive convergence. Traditionally, broadcast networks met the high-availability need with dual diverse connections, but at the cost of double the equipment and network resources. MPLS has inherent advantages over dual diverse connections, without sharing any common network paths or resources, and thereby providing a zero-loss environment.

## **Performance**

With the recent shift to HD video and the increase in the number of HD broadcast channels, demand is growing for high throughput at the infrastructure level. Video delivery over packet networks mandates that the underlying network elements support high performance for packet replication and provide flawless system characteristics for delay, jitter, and packet loss.

The zero-loss requirement for video broadcast demands both superior control plane and forwarding performance of the network elements. Typical interior gateway protocols (IGPs) and multicast protocols take tens of seconds for network convergence in the event of a link or node failure. MPLS became the obvious alternative because of its inherent advantages of protection against link, node, and path failure with its Fast Reroute (FRR) capabilities. MPLS resource reservation and traffic-engineered paths have tremendous advantages for over-the-top (OTT), on-net, and other premium services.

## **Streamlined, Integrated Operations**

Service delivery requirements vary considerably and force service providers to have multiple networks, thus having the potential to appreciably increase delivery costs. Significant savings can be achieved by leveraging common MPLS and P2MP LSP mechanisms. Multicast-based video and content distribution leverage native multicast forwarding using a PIM-like control plane. Point-to-point Layer 2 services require an MPLS and LDP infrastructure for control plane and data plane forwarding. VPLS Ethernet LAN (E-LAN) services leverage several point-to-point Layer 2 circuits to emulate a broadcast network. Layer 2 and Layer 3 VPNs for managed communication services require BGP, MPLS, and LDP technologies. Multicast VPNs, on the other hand, require MPLS, generic routing encapsulation (GRE), and PIM-based technologies for service delivery. Video on demand (VOD) service requires a call-admission mechanism for guaranteed resources for the complete network path and video source.

## **Limitations of PIM-Based Delivery Model**

IP multicast based on PIM infrastructures falls short in meeting the requirements of broadcast and multicast services.

### **Challenges of PIM-Based Service Rollouts**

PIM networks cannot promise subsecond convergence times due to their dependence on integrated routing protocols. PIM provides limited control over the traffic path, as many services depending on multicast routing tend to follow a similar path (the shortest path as computed by the IGP). Predictably, this approach often results in overutilization of some network segments, suboptimal load distribution across the network, and underutilization of links. It can also cause service degradation in the event of bandwidth unavailability or node, link, or path failure.

IP MULTICAST BASED ON PIM INFRASTRUCTURE	P2MP MPLS LSP TE NETWORKS
No resource reservations mechanism available.	Resource reservation using MPLS RSVP.
PIM requires a different operational framework in the core infrastructure than that required for a unicast network.	Simplifies operations by providing a common operational framework for unicast and multicast traffic.
PIM requires multisecond convergence times after network failures.	Uses MPLS Fast Reroute.
PIM lacks multicast traffic path control mechanisms. All services follow common paths that are defined by the traditional IGP's algorithms. Customizing the path for different multicast applications is cumbersome.	Uses traffic engineering to enable different E-LSP and L-LSP paths to be defined explicitly based on application requirements and network state (such as utilization levels and congestion).
PIM requires reverse path forwarding (RPF) unicast route exchange mechanisms that limit scaling performance.	Reduces network overhead by eliminating the need to use PIM and RPF altogether.
MVPNs with PIM as a delivery mechanism require both the PIM and MPLS infrastructures to work together. These traditional MVPN implementations complicate network operations by increasing the protocol complexity and interdependencies between PIM, IP-in-IP (GRE), and MPLS over unicast.	Next-generation (NG) MVPN with P2MP LSPs minimizes the complexity and delivery requirements by enabling greater traffic compartmentalization, security, and bandwidth optimization.
PIM MVPNs have scaling limitations. Every provider edge (PE) needs to maintain a PIM adjacency with a remote PE for each VPN routing and forwarding (VRF) table.	MVPN with P2MP and LSPs completely eliminates these PIM scaling challenges (Figure 1).

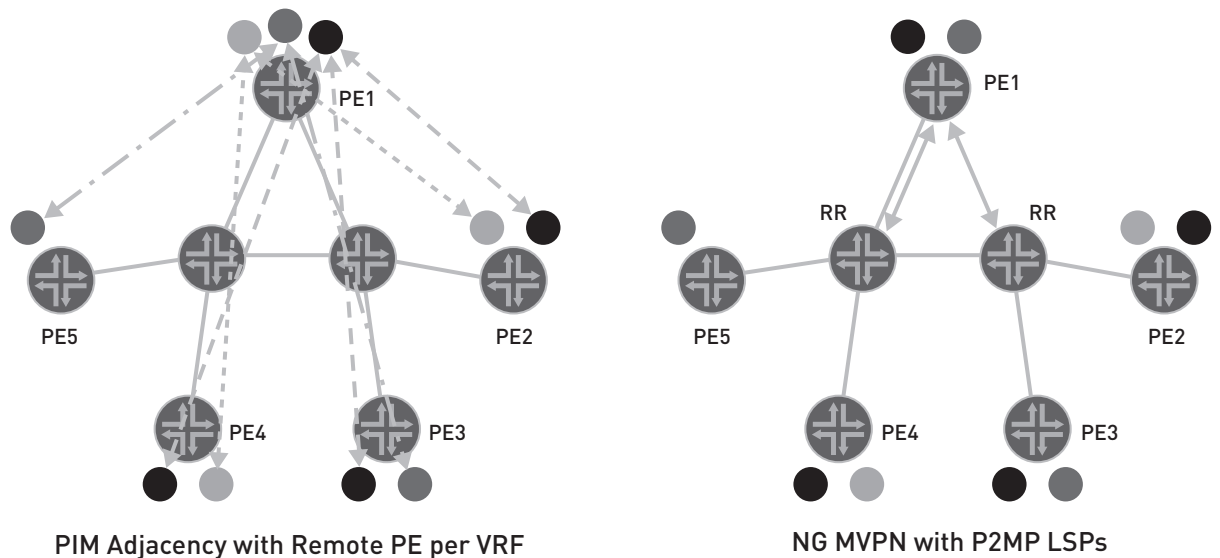


Figure 1: Comparison of MVPN with PIM versus P2MP LSP as a delivery mechanism

**Lack of Control over Multicast and Unicast Traffic**

Many providers still depend on point-to-point transport technologies to offer their broadcast and multicast services. For example, emerging metro Ethernet services based on VPLS, being Layer 2 in nature, cannot use the PIM core, and so network elements replicate broadcast and multicast packets to every egress PE leveraging point-to-point MPLS LSPs. Such services can easily create a choke point on the ingress PE (Figure 2). All multicast traffic in the network between the same pair of nodes will follow the same path and degrade network resource utilization. This approach also creates challenges for bandwidth and high-availability modeling to protect against link and node failures.

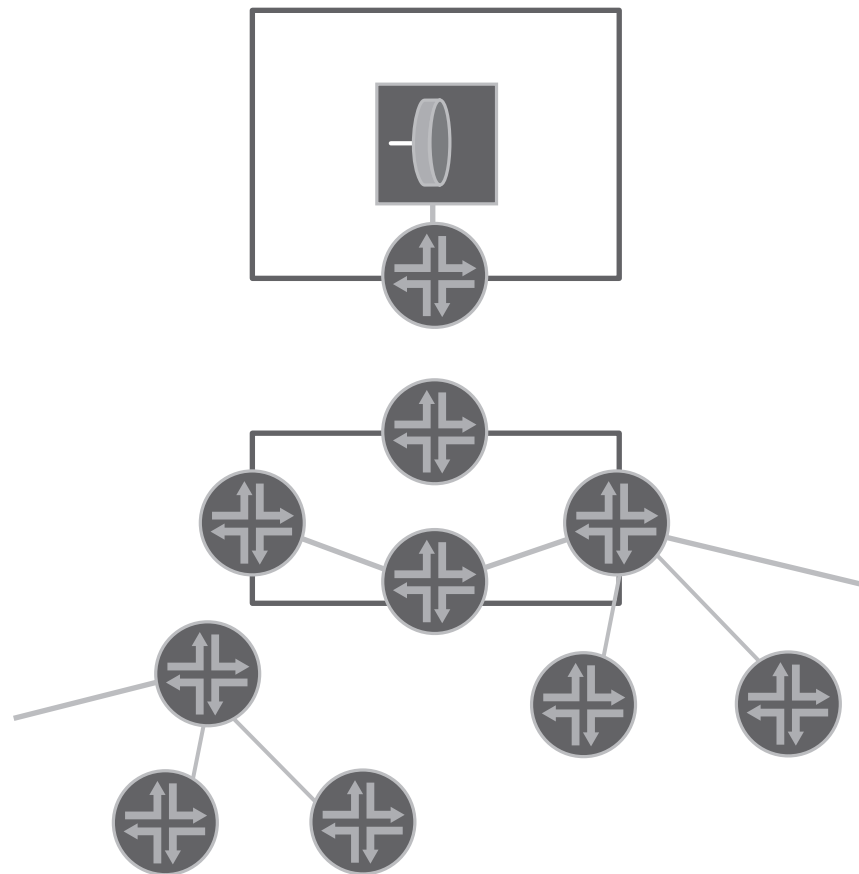


Figure 2: Content distribution with point-to-point LSPs

## Optimizing Multicast-Based Rollouts with High-Performance P2MP LSPs

Juniper Networks pioneered a new technology that leverages MPLS to provide point-to-multipoint transport. This technology is an open-industry standard that is supported by major telecommunications vendors.

A P2MP LSP is an LSP with multiple destinations. It essentially works on the replication capabilities of the network elements (routers and MPLS switches) at the MPLS layer. This approach optimizes bandwidth by eliminating multiple unicast streams, replicating MPLS packets at every relevant or designated branching router and MPLS switch. P2MP LSPs' capability to replicate at the MPLS level addresses a critical shortcoming of legacy multicast deployments.

P2MP LSPs leverage all of the rich and proven MPLS capabilities, such as traffic engineering, better control over service traffic (unicast and multicast), enhanced security, faster convergence, and simpler operation. With minimal change, established Layer 2 and Layer 3 VPN services offer significant savings. For example, proven Fast Reroute mechanisms with convergence times of less than 50 milliseconds are leveraged by P2MP LSP and offer outstanding path, node, and link failure recovery times for video and other real-time applications (Figure 3). P2MP LSP also reduces complexity by eliminating the need for less stable multicast routing protocols. For MVPNs, the Juniper Networks solution can combine MVPN directly with P2MP LSP, thereby avoiding the compounded complications of having to concurrently manage MPLS, IGP, VPN IGP, PIM, and possibly GRE. In the case of VPLS, P2MP LSP eliminates ingress replication choke points by transporting traffic over P2MP LSPs.

In the last 9 to 12 months, these cost-effective benefits have been a driving force behind major service providers, MSOs, and content delivery networks (CDNs) upgrading their networks to use P2MP LSPs.



## References

World's First MPLS Network for Video with Traffic Engineering, Announced in May 2005

[http://findarticles.com/p/articles/mi\\_m0EIN/is\\_2005\\_May\\_19/ai\\_n13729744](http://findarticles.com/p/articles/mi_m0EIN/is_2005_May_19/ai_n13729744)

IP/MPLS Broadcast Network for ITV

[http://findarticles.com/p/articles/mi\\_m0ECZ/is\\_2005\\_May\\_20/ai\\_n13830047](http://findarticles.com/p/articles/mi_m0ECZ/is_2005_May_20/ai_n13830047)

Orange UK: MPLS P2MP LSPs for IPTV Distribution

<http://uppersideconferences.com/mpls2008/mpls2008agendaupdates.htm>

Point to Multipoint Traffic Engineering with MPLS

[http://media.frnog.org/FRnOG\\_8/FRnOG\\_8-2.pdf](http://media.frnog.org/FRnOG_8/FRnOG_8-2.pdf)

## About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses. Additional information can be found at [www.juniper.net](http://www.juniper.net).

---

### Corporate and Sales Headquarters

Juniper Networks, Inc.  
1194 North Mathilda Avenue  
Sunnyvale, CA 94089 USA  
Phone: 888.JUNIPER (888.586.4737)  
or 408.745.2000  
Fax: 408.745.2100  
[www.juniper.net](http://www.juniper.net)

### APAC Headquarters

Juniper Networks (Hong Kong)  
26/F, Cityplaza One  
1111 King's Road  
Taikoo Shing, Hong Kong  
Phone: 852.2332.3636  
Fax: 852.2574.7803

### EMEA Headquarters

Juniper Networks Ireland  
Airside Business Park  
Swords, County Dublin, Ireland  
Phone: 35.31.8903.600  
EMEA Sales: 00800.4586.4737  
Fax: 35.31.8903.601

To purchase Juniper Networks solutions, please contact your Juniper Networks representative at 1-866-298-6428 or authorized reseller.

Copyright 2010 Juniper Networks, Inc. All rights reserved. Juniper Networks, the Juniper Networks logo, Junos, NetScreen, and ScreenOS are registered trademarks of Juniper Networks, Inc. in the United States and other countries. All other trademarks, service marks, registered marks, or registered service marks are the property of their respective owners. Juniper Networks assumes no responsibility for any inaccuracies in this document. Juniper Networks reserves the right to change, modify, transfer, or otherwise revise this publication without notice.