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INSIGHT

The Role of MPLS in Next-Generation IP/Ethernet Access and Aggregation Networks

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IDC OPINION

Service providers are increasingly focusing their investments on the convergence of their wireline and wireless telecom network infrastructure assets due to economic reasons. However, they aim to do this without compromising support for high-bandwidth growth rates. Recent advances in packet transport technology such as MPLS-TP will help service providers plan a large-scale migration from circuit-switched to packet transport. Consumption of IP/Ethernet data bandwidth continues its torrid growth, driven by the proliferation of mobile devices, high-bandwidth datacenter connectivity, enterprise VPNs, and cloud-based services, which are forcing capacity overhauls of the mobile backhaul, IP, and Carrier Ethernet (CE) access and aggregation networks. With recent industry and standards initiatives in the IETF and ITU, MPLS has evolved to become the unifying packet transport technology with the addition of significant transport engineering capabilities. In the long term, a standards-based MPLS network access infrastructure solution should offer service providers:

- Lower life-cycle opex than alternative packet technology or optical networking options using simpler data plane and enhanced operations and maintenance (OAM) flexibility to support the growing bandwidth and networking requirements for the converged mobile and wireline IP networks of the future
- The ability to leverage the existing investments in MPLS core and edge infrastructure, technology, services, and new extensions, such as MPLS-TP, to enable more capabilities per dollar invested in MPLS
- Standardized network optimization tools and multivendor MPLS interoperability

IN THIS INSIGHT

This IDC Insight examines the role that recent MPLS technology enhancements supporting the evolution of circuit-switched transport to packet switched network will play in service providers' next-generation access and aggregation network infrastructure.

This document provides an analysis of MPLS in access and aggregation networks and the role of MPLS-TP and MPLS enhancements to configure IP and Ethernet circuits end to end from routers located near the network edge through an optical core and back to routers located near the network edge at the opposite end of the connection. This document also addresses how MPLS may address the packet and transport network convergence opportunities.

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SITUATION OVERVIEW

Introduction

MPLS was created to improve packet performance and control traffic in the core of the Internet and private IP networks. While it continues to be widely used for that purpose, it has also been adapted for other uses. MPLS encapsulates data packets, adding packet headers that enable a variety of features; provides a rich set of control and monitoring functions; and is in wide use in business-oriented and performance-critical services. MPLS offers security features and enhanced quality of service (QoS).

Most carriers have deployed MPLS within their optical core and edge networks to transport and deliver IP and Internet services for over 10 years, enabling the core and edge network to act much like a TDM transport network but with a greater level of efficiency. Some carriers are now looking to achieve the same result in their access, aggregation, and backhaul networks using MPLS-TP and other forms of MPLS, thus ensuring their transport networks can provide end-to-end packet performance control for the growing number of IP services.

Migration Drivers to Packet Transport

Bandwidth capacity growth rates across global telecom networks continue to grow by triple digits each year with bandwidth-intensive applications like IPTV, mobile video, storage networking, and cloud data services continuing to drive growth. These applications put more pressure on service providers to minimize the cost per bit and maximize the value per bit, forcing them to transition their transport networks from circuit-based technologies to packet-based technologies. Newer IP-based service offerings offer faster turn up, more stringent SLAs, higher bandwidth speeds, and high availability to meet enterprise requirements. This transition is putting more economic strain on service providers that are seeing the traffic shift from mostly circuit-based TDM/OTN traffic to an increasing mix of packet traffic for Ethernet and IP services.

Mobile IP traffic is also playing an increasing role in the traffic growth within access and aggregation networks. In 2010, for example, the Organisation of Economic Co-operation and Development (OECD) Communication Outlook 2011 reported that 1% of the global IP traffic was over mobile networks, and this will grow to 8% by 2015. As data and video services over wireless devices continue to accelerate, deployment of packet-based Ethernet backhaul aggregation for 2G/3G/LTE is becoming more critical for mobile operators that have a myriad of legacy TDM- and ATM-based backhaul networks. By employing MPLS pseudowire, which is an encapsulation solution that can support native TDM, ATM, and packet traffic in the aggregation and access networks, mobile operators and wireline service providers are converging their backhaul traffic without compromising service quality.

IDC estimates CE enterprise services will exceed $25 billion globally in 2012 and are growing at a CAGR of 18–20% over the next 4 years (see *U.S. Carrier Ethernet Services 2011–2015 Forecast,* IDC #231257, November 2011). Enterprises of all sizes and vertical industries continue to adopt and replace their existing private line and packet services with Ethernet. This explosion of CE enterprise services will increase the amount and proportion of the packet traffic in the access and aggregation networks. According to IDC's 2011 WAN survey, more than 30% of enterprises are now utilizing CE services with 100Mb–1GB bandwidth per site compared with less than 10% 2 years ago.

For the past 10 years, service providers have been able to employ various generations of ATM and MSPP products to transport SONET/SDH traffic along with packet traffic with POSONET/SDH interfaces, but this is changing as packet-switched traffic overtakes circuit-switched traffic in wireline networks. According to IDC, of the 4.2 trillion in global enterprise voice minutes in 2011, 26% were VoIP compared with just 10% 4 years ago.

As a result of this growth, service providers are scrambling to provide capacity and engineer their networks for higher-value end-to-end IP-based services. Migrating their existing legacy packet and transport networks, made up mostly of SONET/SDH transport, MSPP, and ATM/FR packet switches, is becoming cost prohibitive because of higher opex, end-of-life status, and escalating maintenance costs.

Today, higher-capacity optical switching technologies (OTN) are being employed for 40G/100G transport links within metro and selected WAN routes where the routes are static and the requirement is for high availability and large "fat" pipes. But for the access and aggregation networks, this type of solution does not provide the optimal use of transport resources. Packet-based enterprise, wholesale, and backhaul solutions requirements include classifying and grooming the IP traffic and optimizing the use of network capacity in more granular increments of 10MB, 100MB, 1GE, or even 10GE.

For most service providers that operate IP networks, the data service organizations and operations staff have become familiar with MPLS/IP technologies and have been able to leverage that investment and expertise over the years as MPLS has evolved into a mature and rich set of features on their installed network infrastructure. The data services and transport organizations have often worked in operational silos, each focused on different requirements and different customers. However, a paradigm shift is happening as the increase of IP/Ethernet traffic in both wireline and mobile networks and the increased use of on-demand bandwidth services become more widely available. Service providers are starting to realize the economies of consolidating their legacy voice, data, and IP network infrastructure into an integrated multi-access network that can support any or all wholesale, enterprise, residential, and mobile services.

This migration from TDM transport to packet optical transport, though, requires key capabilities like diversity for outages, low latency, restoration time, high availability, and simpler OAM as well as an overall focus on reducing opex.

Requirements for Next-Generation Service Provider Access and Aggregation Networks

Service providers are looking to MPLS technology and its transport-related enhancements to solve many of the challenges facing service providers in the access and aggregation sections of the network.

One of the key challenges of these types of networks is scaling — unlike in core and edge networks. Access and aggregation networks often have to support thousands of nodes, which require considerable configuration and network operational complexity if full IP routing tables have to be instantiated.

Next-generation access and aggregation networks have to be packet-optimized transport networks that can leverage statistical multiplexing, burst capabilities, and use all of the available bandwidth capacity. These networks must support flexible data rates and on-demand services like virtual storage, cloud-based applications, and VPNs while supporting real-time services including legacy TDM services.

Service providers also expect the same level of OAM functionality in an MPLS transport solution as they have in current transport networks. This is a critical area for service providers to control opex.

The next-generation access network must support fast protection switching at sub-50ms, which is equivalent to current SONET/SDH networks and provides network resiliency. Automatic backup and recovery of circuits, restoration of paths, and physical diversity of networks are also important requirements. Automating service provisioning, troubleshooting, and proactive monitoring are key components of lowering opex and simplifying the management of the network and transport elements.

Service providers are also trying to reduce the number of strategic infrastructure vendors and the number of different network elements as they strive to reduce overall opex, sparing, and vendor support costs. This overall consolidation may accelerate the migration of newer technology into the transport network.

What Is MPLS-TP and Unified MPLS?

MPLS-TP is reliable, packet-based Layer 2 technology developed during 2008–2010. It is based upon circuit-based transport networking concepts and provides connection-oriented services, but without a distributed control plane, by employing manually provisioned label-switched paths without endpoint router identifiers. MPLS-TP includes OAM capabilities, resilience, monitoring, and management handled by the data plane, and the data/forwarding plane is essentially the same as the MPLS forwarding operation, with OAM signaling being achieved by a reserved MPLS label.

This OAM replicates the transport-centric operations familiar to TDM operators and provides a simple mechanism for validating that the data path is operational in the network. In addition, MPLS-TP supports restoration mechanisms based on a backup path rather than single link or node protection. While this approach is not typically feasible in core networks, it is a viable solution for access networks and simplifies operations.

MPLS-TP supports important restoration requirements for transport networks including end-to-end primary and backup network paths using the Bidirectional Forwarding Detection (BFD) protocol, which ensures uninterrupted transport connectivity.

The goal of MPLS-TP is to simplify service providers' transport network, lower TCO, and improve the economics of transporting IP data with a simple-to-operate and resilient end-to-end packet transport network. The initial phase of MPLS-TP is already deployed in a number of network equipment vendors' MPLS switches and routers, and service providers are already deploying MPLS-TP in access and aggregation solutions.

For example, Bharti Airtel is deploying MPLS-TP throughout its access and aggregation network to support 2G/3G/4G mobile backhaul in India for Ethernet, IP, TDM, and ATM traffic. It allows Bharti to leverage MPLS-TP's transport-oriented operation to support both legacy TDM circuits for 2G/3G and future packet-based 4G/LTE services.

Another Tier 1 wireline telecom operator is transitioning its metro core/aggregation networks from a SONET/SDH transport solution to packet transport using MPLS-TP. This operator will now be able to support the existing legacy enterprise private line, residential broadband, and 2G/3G cell site backhaul in addition to its fast-growing Ethernet services, IP VPN from the same architecture, and vendor platforms. This service provider plans to employ a GMPLS control plane to manage the scaling and utilize its DWDM infrastructure, which will be used to transport MPLS-TP connections within the metro core. Following that, the service provider will interconnect its enterprise, wholesale, and residential customers via each service access network with MPLS-TP.

The concept of "Unified MPLS" provides an overall end-to-end MPLS network architecture that combines all of the latest developments within MPLS. This includes MPLS-TP to support simplified and highly scalable Ethernet and MPLS/IP service deployments extending the flexibility of both a static and a dynamic MPLS control plane. Unified MPLS gives service providers the choice of using full-featured Layer 3 MPLS for specific IP service requirements and to provide every network segment that is involved with packet switching the option of using some form of MPLS, like MPLS-TP. This combines the network service and access services via an MPLS access, aggregation, edge, and core network with a unified control plane to simplify the OSS and network management of next-generation IP networks. This provides a nice migration from multiple legacy and IP transport networks to simpler network architecture of fiber/DWDM, MPLS, and IP with carrier-grade OAM and better scalability flexibility than pure Ethernet transport solutions.

Verizon is using MPLS-TP and a unified MPLS architecture to set up dynamic connections across its DWDM/OTN core network to provide interconnectivity between its CE and private IP service access networks. Verizon's intent is to leverage this unified MPLS architecture to converge all of the company's packet services and traffic across an MPLS-TP backbone. It will also enable more enterprise with bandwidth-on-demand services as well as improve traffic engineering across the core with dynamic bandwidth management capabilities from end to end.

Why MPLS and Not Connection-Oriented Ethernet?

In recent years, service providers have also been evaluating connection-oriented Ethernet alternatives that include Provider Backbone Bridging (PBB-TE) and Ethernet Tag Switching technology for use in transport networks. Both of these solutions focus mostly on point-to-point connections and rely on Ethernet addressing schemes that are less likely to be widely deployed in a service provider network. Service providers need more compelling economic reasons and more vendors that provide support for this type of technology solution along with multivendor interoperability. Today, there are only a few vendors supporting this, including Fujitsu and Ciena.

Ethernet switching technology does have the potential to become a transport alternative for some service providers, but often the existing 4K VLAN scaling limitation and existing Ethernet VLAN tagging technology can introduce operational issues and interoperability challenges with existing MPLS networks. Wireline service providers face the challenge of reengineering access networks, which are different and prefer to avoid the complexity of translating VLAN tags across enterprise and service provider networks, to accommodate the Ethernet OAM.

Extending MPLS to access networks is more likely because service providers already understand and know how to deploy MPLS and have made the investment in MPLS technology in their core and edge networks. The vendor and service provider community working through the IETF and ITU have made MPLS more resilient and simpler to operate for access networks, which until recently have been a stumbling block. Also, many of the leading network infrastructure vendors including Cisco, Juniper, Ericsson, Alcatel-Lucent, Ciena, ECI, and Huawei have products and solutions that support MPLS-TP. Cisco and Ericsson support unified MPLS solutions.

MPLS-based solutions offer flexibility for service providers to adapt and use MPLS in different network and operational models. There are two primary approaches for bringing MPLS to access networks. The first approach aligns with using a static control plane for MPLS (as represented by the initial phase of MPLS-TP). The second approach uses developments in the dynamic control plane of MPLS. The end-to-end or unified MPLS architecture positions MPLS in the data and control plane for every network element performing packet switching in the SP networks' static or dynamic control plane for access networks.

Other new MPLS transport enhancements like Loop Free Alternative (LFA) ensure fast restoration times at sub-50ms, which are expected in modern transport networks.

In a modern mobile backhaul network, MPLS can enable different service models. For example, today's Ethernet switches can be configured to run a link state routing protocol (Layer 3), which will enable imminent 4G/LTE services and can offer service providers the flexibility to offer any-to-any connectivity for LTE services with the fast restoration of LFA.

Alternatively, a service provider may choose to employ MPLS-TP in a static point-to-point backhaul configuration for access network control and often as a wholesale-retail business model.

Another MPLS innovation is label allocation Downstream on Demand, which offers an alternative approach for bringing MPLS to access networks using a simple label distribution protocol implementation without the need to increase routing protocol complexity. LDP Downstream on Demand allows very simple devices, such as DSLAMs and PON equipment with limited memory and CPU resources, to participate in end-to-end MPLS with acceptable operational characteristics.

FUTURE OUTLOOK

The role of MPLS in supporting future packet transport requirements for next-generation IP access and aggregation networks is in its early stages. As the IETF and ITU finally come to a consensus, vendors are busy incorporating MPLS-TP and other MPLS enhancements in their networking products, enabling MPLS transport network-friendly solutions for service providers.

Strong demand for packet transport capabilities for Ethernet/IP-based mobile backhaul and for high-bandwidth enterprise IP/Ethernet services will continue to accelerate the migration from SONET/SDH and OTN architecture to packet transport networks. MPLS-TP and unified MPLS will become an integral part of the service provider's next-generation architecture. Many service providers plan to conduct lab and field trials for MPLS-TP and unified MPLS during the next 12–36 months.

IDC expects to see different use cases evolve for MPLS in the access and aggregation networks of service providers, including:

- Wholesale services model, where the service provider must establish an aggregation point of demarcation for the different operational groups or companies to manage their own entities

- RAN deployments, where the address entries are only needed up to the position of the radio network controller in the network because of separate routing domains

- New service provider OAM requirements to support new high-bandwidth enterprise services such as mobile data services, mobile videoconferencing services, cloud services, and hybrid VPN services that require more latency-sensitive, application-aware, and increased bandwidth flexibility for always-on (connection-oriented) and on-demand requirements.

IDC expects that Cisco, Juniper, ECI Telecom, and Ericsson, the most proactive vendors supporting the use of MPLS in access and aggregation networks, will continue to invest resources and product development in evolving MPLS enhancements for their respective products. Features that are optimized for access and aggregation network uses will continue to distinguish each vendor's solution. IDC expects to see these vendors aggressively position MPLS as a key technology building block for service providers' next-generation IP-packet network infrastructure for both mobile and wireline transport networks. These vendors are among the leading vendors also helping drive MPLS-TP and other enhancements to become standardized within the ITU and IETF.

In the near future, MPLS vendors will need to be able to demonstrate to service providers the economic benefits of capex and opex reductions resulting from MPLS deployments in access and aggregation networks. Finally, vendors will need to articulate how they differentiate their respective MPLS solutions in access and aggregation deployments.