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In this issue

MPLS Transport Profile: Next Generation Transport Networks

Multi Protocol Label Switching (MPLS)

Traditional IP routing is connectionless and packets undergo analysis at each hop, followed by forwarding decision using network header analysis and lookup in routing tables. This hop-by-hop destination-based unicast routing makes transmission of packets comparatively slower. MPLS, on the other hand, does not have to examine the header at each router and thus routes packets from a source node to a destination node across networks at a much faster rate. MPLS was originally developed by Internet Engineering Task Force (IETF) to deliver a cost-efficient way of routing traffic in high performance core networks. It has since found strong application in provision of Layer 3 or Layer 2 virtual private networks (VPN).

The MPLS architecture is split into two separate components: the forwarding component (also called the data plane) and the control component (also called the control plane). The forwarding component uses a label-forwarding database maintained by a label switch to perform the forwarding of data packets based on labels. The control component is responsible for creating and maintaining label-forwarding information among a group of interconnected label switches. Dynamic routing protocols or static configuration builds the database needed to analyze the destination IP address (viz the routing table). In an MPLS network, as a packet enters ingress router, MPLS assigns the packets with short-fixed length labels for data transmission across the network. These labels carry the information, which enable each switching router on how to process and forward packets to destination. As each node forwards the packet, it swaps current label for the most appropriate label to the subsequent node to route the packet. When a packet reaches the egress router, the labels are removed and the packet is forwarded to destination IP network.

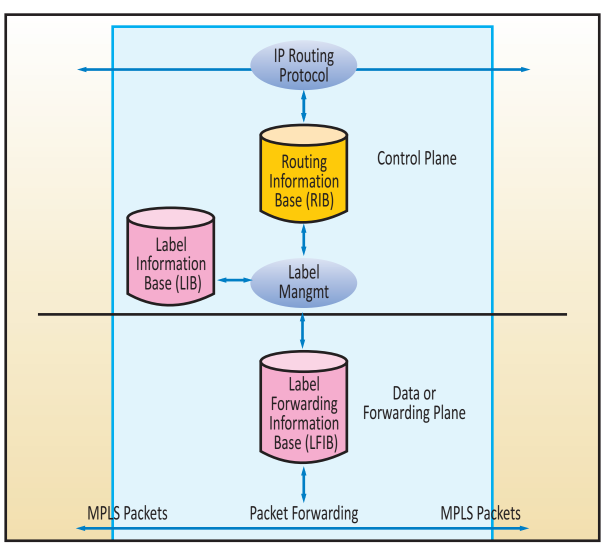

Figure1 MPLS Architecture

Packet header is analyzed only once while they enter the MPLS cloud from then the forwarding decision is 'label-based' thus reducing processing at each node and ensuring fast packet transmission. The label based forwarding ensures end-to-end circuits over any type of transport medium using any network layer protocol.

MPLS and Traffic Engineering

MPLS network are capable of implementing Traffic Engineering to take care of network blockages and boost performance. Traffic engineering refers to the process of selecting LS paths chosen by data traffic in order to balance the load on various links, routers, and switches in the network. This is more useful in networks where multiple parallel or alternate paths are available. All routing techniques in use are modified to map packet data to network resources. Such a mapping process can handle bottlenecks of packet overcrowding with suppression of latency, jitter, and loss factors. When link failure occurs, Fast Reroute of MPLS TE uses backup tunnels to reroute the traffic over the secondary link. A satisfactory level of free capacity is necessary for smooth functioning. In spite of this backup method, frequent failures of network nodes will lead to constant traffic congestion on alternative paths reducing its efficiency overall. Quality-of-Service mechanisms maintain bandwidth for the tunnels that operate as a backup. MPLS Fast Reroute functionality handles link or node failures by directing encapsulated traffic to a preconfigured secondary path when the primary one fails. This is not possible in case of IP networks, as redirecting mechanism is not applicable here.

A 3-bit Class of Service (CoS) value prioritizes traffic for transmission. At the ingress edge, the arriving IP packet is marked with CoS value and they are encoded for reference in MPLS header. This provides fast packet transmission between nodes to avoid network congestion.

Traffic Engineering in MPLS

Traffic Engineering in MPLS involves the technique of directing traffic that flows within a network. Several routing procedures implement packet forwarding for a secure transmission. The following advantages enhance traffic engineering:

- MPLS TE directs traffic from congested paths to under-utilized path available to alleviate traffic congestion.
- MPLS allows Fast Reroute around link/node failure and increases network reliability and uptime.
- It provides deployment flexibility by allowing any combination of circuits with E1, E3, optical carriers, or Ethernet to be assimilated into an MPLS setup.
- MPLS Class of Service (CoS) functions are Committed Access Rate (CAR), Weighted Random Early Detection (WRED), and Weighted Fair Queuing (WFQ). Each service class implement traffic engineering by classifying traffic based on available bandwidth in links, manage packet overflow in edge routers, drop probability and network traffic control using algorithms.

Limitations of Traffic Engineering in MPLS

While MPLS renders several gains over its implementation, there are the following technical downsides as well:

- A satisfactory level of free capacity is necessary for smooth functioning. Even if such a backup is available, frequent failures of network nodes will lead to constant traffic congestion on alternative paths reducing its overall efficiency.
- To implement traffic engineering, paths require manual configuration irrespective of the presence of Internet Protocol for packet routing. If intermediary nodes are not configured manually, then MPLS TE traffic does not gain importance is treated same as of the regular IP or MPLS traffic.
- There is dependency on appropriate protocols for automatic rerouting. OSPF (Open Shortest Path First) or IS-IS protocol (Intermediate System to Intermediate System) is required for automatic path calculation and systematic rerouting of IP traffic in MPLS TE paths. LDP is required in MPLS VPNs for creating tunnels.
- Quality-of-Service mechanisms maintain bandwidth for the tunnels that operate as a backup. Intermediate nodes in TE path do not have manual configuration option. Traffic using Fast Reroute on the alternative path will stumble over link failures. Therefore there is performance variation in case of MPLS Fast reroute.

MPLS-Transport Profile (MPLS-TP)

Not all of MPLS's capabilities are needed in, or are consistent with, transport networks. Many service providers worldwide are looking for solutions that will optimize MPLS for transport, simplify operations and management of packet-based networks and pave way for a more cost-effective extension of MPLS functionality into the access network. This standardized approach is known as MPLS Transport Profile (MPLS-TP) in the IETF (groups – MPLS, PWE3, and CCAMP) and the ITU-T SG15 since 2008.

A number of operators believe that cost savings can be achieved by deploying a solution that is strictly connection-oriented and does not rely on IP routing and are supporting development of MPLS-TP. A year after holding its first meeting in early 2008, the IETF released RFC 5317 titled "MPLS Architectural Considerations for a Transport Profile." The report recommended that the IETF and the ITU-T work together to "bring transport requirements into the IETF and extend IETF MPLS forwarding, OAM, survivability, network management and control plane protocols to meet these requirements through the IETF standards process. ITU-T accepted this recommendation and the two organisations committed to establishing a single standard that would become a fully compliant MPLS protocol and supersede the ITU-T's earlier work on T-MPLS. After much effort and debate among IETF and ITU-T members, the core elements of the MPLS-TP standard are largely complete. While a few hurdles remain to be overcome, era of standardized MPLS-TP technology is beginning to emerge and is poised to impact the way converged networks are built in coming years. In 2011, after years of joint development between the ITU-T and IETF, MPLS-TP has emerged as the technology of choice for next-generation transport networks and is being put to test in multi-vendor interoperability trials.

Smart Community

A smart community is a multihop network of smart homes that are interconnected through radio frequency following wireless communication standards such as WiFi (IEEE 802.11) and the third generation (3G) of mobile telephony. It can be viewed as a cyber-physical system, in which homes are virtually multifunction sensors with individual needs, continuously monitoring the community environment from various aspects; and, when necessary, automatic or human-controlled physical feedback is input to improve community safety, home security, healthcare quality, and emergency response abilities.

Architecturally, a smart community consists of three domains: the home domain, community domain, and service domain. In home domain, a home network is formed by a number of home automation systems (e.g., healthcare systems and security systems) for continuous real-time monitoring of residents, the home environment, and the nearby community environment (e.g., the street segments beside a house). The core of the smart community architecture is the community domain, where a connected community network is formed by home gateways (representing their hosting homes) for cooperative and distributed monitoring of the community environment and information dissemination among individual homes. The key component of this domain is a *call center*, which is a communication and computation device hosted by a trusted party like the local police department.

Source: IEEE Communication Magazine, November 2011

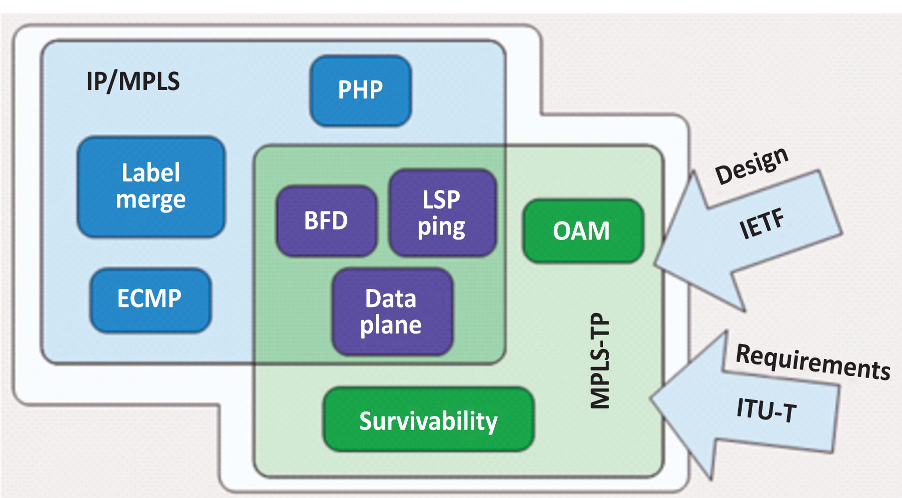

Figure 2: The MPLS, MPLS-TP overlap

ECMP : Equal Cost Multiple Path
BFD : Bidirectional Forwarding Detection
PHP : Penultimate Hop Popping
LSP : Label Switch Path
OAM : Operation, Administration and Management

Emerging MPLS-TP technology is both a subset and an extension of MPLS. It bridges the gap between the packet and transport worlds by combining the packet efficiency, multiservice capabilities and carrier-grade features of MPLS with the transport reliability and OAM tools traditionally found in SDH. The MPLS-TP proposal contains a set of compatible technology enhancements to existing MPLS standards to extend the definition of MPLS to include support for traditional transport operational models. This proposal adopts all of the supporting quality of service (QoS) and other mechanisms already defined within the standards, but also brings the benefits of path-based, in-band Operations, Administration, and Maintenance (OAM) protection mechanisms (switchover to backup path within 50ms) and Network Management System (NMS) found in traditional transport technologies. It is a simplified version of MPLS for transport networks with some of the MPLS functions turned off, such as Penultimate Hop Popping (PHP), Label-Switched Paths (LSPs) merge, and Equal Cost Multi Path (ECMP). MPLS-TP does not require MPLS control plane capabilities and enables the management plane to set up LSPs manually. Its OAM may operate without any IP layer. MPLS-TP simplifies the application scenarios of MPLS with decreased equipment, operation and maintenance cost. The data plane is separated from the control plane, which leads to higher network stability, reliability and flexibility.

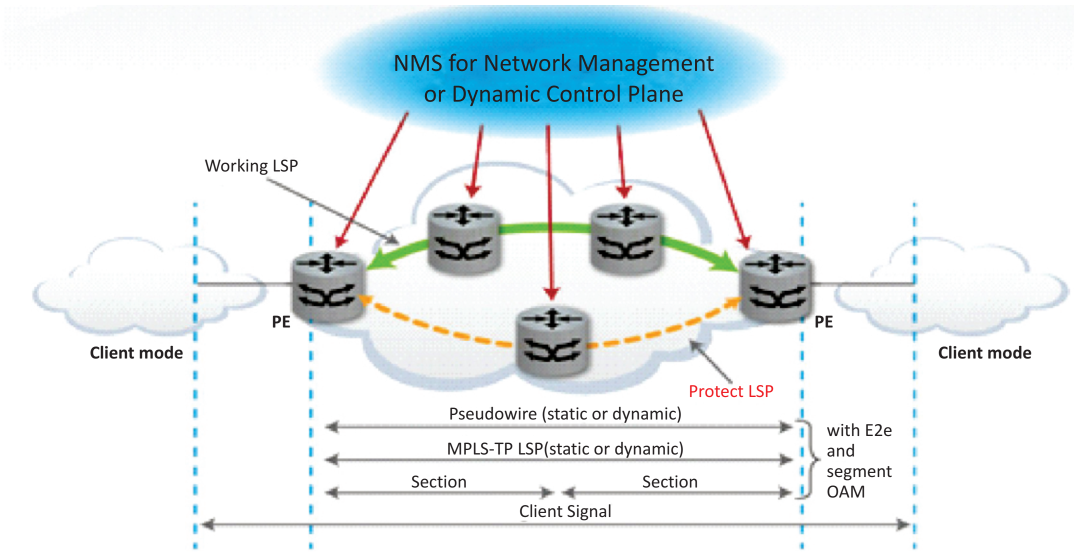

Figure 3 MPLS-TP Framework

Objectives of MPLS-TP

The primary objectives for the development of MPLS-TP are (1) to enable MPLS to be deployed in a transport network and operated in a similar manner to existing transport technologies and (2) to enable MPLS to support packet transport services with a similar degree of predictability to that found in existing transport networks. The idea is to give operators the option to deploy MPLS-TP anywhere in the core, metro/aggregation and access networks. In order to achieve these objectives, there was a need to define a common set of MPLS protocol functions — an MPLS Transport Profile — for the use of MPLS in transport networks and applications. Some of the necessary functions are provided by existing MPLS specifications, while others require additions to the MPLS tool-set.

Features of MPLS-TP

The essential features of MPLS-TP defined by IETF and ITU-T are:

- MPLS forwarding plane with restrictions
- PWE3 Pseudowire architecture
- Control Plane: static or dynamic Generalized MPLS (G-MPLS)
- Enhanced OAM functionality
- OAM monitors and drives protection switching
- Use of Generic Associated Channel (G-ACh) to support fault, configuration, accounting, performance, and security (FCAPS) functions
- Multicasting is under further study

Working of MPLS-TP

MPLS-TP is a variant of the traditional MPLS services that have been in use for many years in IP networks. It uses Generalized MPLS (GMPLS) to provide deterministic and connection oriented behavior using LSPs (Label Switched Paths), making it a dependable transport protocol. MPLS-TP also uses Targeted LDP (T-LDP) to set up pseudowires (PWs) over GMPLS LSPs, to provide VPWS (Virtual Private Wire Service) and VPLS (Virtual Private LAN Service). MPLS-TP mandates running protocols such as BFD (Bidirection Forwarding Detection) over GMPLS LSPs and PWs, to provide OAM functionality. It does not assume IP connectivity between devices, and explicitly rules out related features of normal MPLS, such as PHP (Penultimate Hop Popping, ECMP (Equal Cost Multipath), and LSP Merge. MPLS-TP specifies how very fast protection and restoration will be achieved using switchover to backup paths. MPLS-TP allows LSPs and PWs to be signaled using a control plane (using RSVP-based GMPLS signaling and Targeted LDP signaling), or to be statically configured.

Applicationsof MPLS-TP

Mobile Traffic Backhaul over Packet Network

Mobile backhaul has emerged as one of the key initial applications for MPLS-TP partly because it fits well with the transport oriented operational model of many mobile operators that currently use TDM –based platforms to support 2G/3G traffic backhaul. MPLS-TP enables operators to deploy simple, inexpensive spoke devices at cell sites, handle multiple traffic types (eg. TDM, ATM, Ethernet, IP), support multiple classes of service, simplify provision and increase fault resiliency via multiple protection options-including mesh topology protection for LTE.

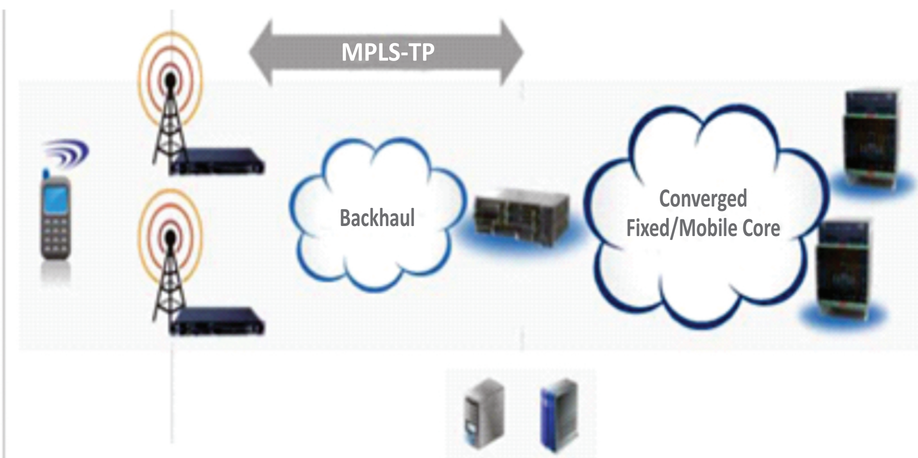

Figure 4 MPLS-TP application: Mobile Traffic Backhaul over Packet

Elastic Optical Networking: A New Dawn for the Optical Layer

Optical networks are undergoing significant changes, fueled by the exponential growth of traffic due to multimedia services and by the increased uncertainty in predicting the sources of this traffic due to the ever changing models of content providers over the Internet. The change has already begun: simple on-off modulation of signals, which was adequate for bit rates up to 10 Gb/s, has given way to much more sophisticated modulation schemes for 100 Gb/s and beyond. The next bottleneck is the 10-year-old division of the optical spectrum into a fixed "wavelength grid," which will no longer work for 400 Gb/s and above, heralding the need for a more flexible grid. To properly address this challenge, one needs flexible and adaptive networks equipped with flexible transceivers and network elements that can adapt to the actual traffic needs. Fortunately, the same technologies that are being considered for achieving very high bit rates at 100 Gb/s and beyond can also provide this added flexibility. The combination of adaptive transceivers, a flexible grid, and intelligent client nodes enables a new "elastic" networking paradigm, allowing SPs to address the increasing needs of the network without frequently overhauling it.

Source: IEEE Communications Magazine, Feb 2012

Metro Access and Aggregation

A number of service providers worldwide are looking at deploying MPLS-TP to migrate their metro core/aggregation networks from TDM to packet transport. The idea is for the MPLS-TP to have a similar look and feel as the existing SONET/SDH network, but scalability can be enhanced with a GMPLS control plane. In the typical scenario, DWDM could be used to transport MPLS based LSPs in the metro core/aggregation network, and these LSPs would interconnect customers on the access side with IP/MPLS, Ethernet or TDM based service cores. The unified MPLS strategy, using MPLS from core to aggregation and access (e.g. IP/MPLS in the core, IP/MPLS or MPLS-TP in aggregation and access) appear to be very attractive to many SPs.

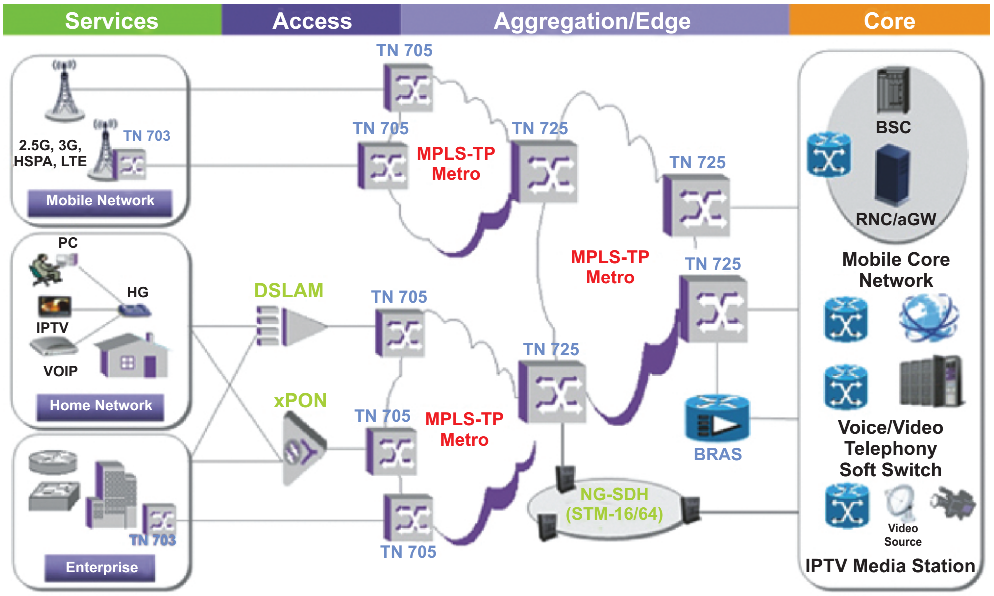

Figure 5 Applications of MPLS-TP in Aggregation and Access networks

It streamlines the operation, help to reduce the overall complexity and improve end-to-end convergence. It leverages the MPLS experience, and enhances the ability to support revenue generating services.

Packet Optical Transport

Many SP's transport networks consist of both packet and optical portions. The transport operators are typically sensitive to network deployment cost and operation simplicity. MPLS-TP is therefore a natural fit in some of the transport networks, where the operators can utilize the MPLS-TP LSP's (including the ones statically provisioned) to manage user traffic as "circuits" in both packet and optical networks.

MPLS-TP in Utility networks

Utilities are increasingly turning to packet technologies as they upgrade to support Smart Grid applications, video surveillance and substation WAN access. With the move to packet networks, security will become the major issue. The centralization of the control plane with MPLS-TP also simplifies the approach that operators /utilities may use to secure network. Since many network vulnerabilities are exploited via TCP/IP attacks, a network of MPLS-TP elements without interface IP address can reduce the risk profile of these mission critical networks.

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