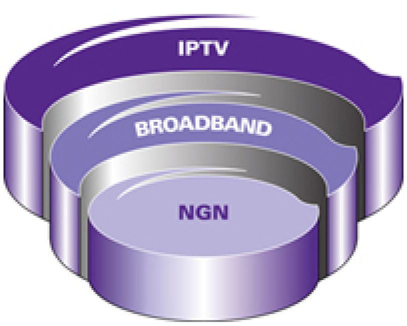
MPLS-TP based
Packet Transport Networks

Delivering new value through next-generation transport networks



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Introduction

In today's challenging economic times, consumers are trying to minimize their expenses by spending money on the right products and services. For service providers, meeting these customer requirements on their existing infrastructure is a major challenge, especially at suitable profit margins.

With the fierce competition that is occurring, service providers need to defend their existing service revenues and stimulate demand growth with new services. Competition is dictating attractive prices, faster service creation and delivery, and an enhanced user experience.

Service providers have realized that a customer taking multiple services is far more lucrative than a customer taking a single service. It is even more lucrative if the same infrastructure can be used to offer these multiple services. This type of service convergence is changing telecom business models. However, responding to changing business models adds new challenges on network infrastructures:

⇒ Enterprises demand advanced business solutions to drive improved customer value and efficiency

⇒ Consumers demand rich content and bundled services

⇒ End users want access to their services anytime, anywhere, on any device

⇒ Multimedia and converged services require improved service provider billing capabilities

⇒ With multiple technologies, services and devices, communications is becoming increasingly complex; building customer loyalty requires a simple, end-to-end experience, regardless of technology.

The overall trend towards convergence of services offers significant opportunities; however, legacy telecom networks are ill equipped to support these offerings. At the same time, multiple technology developments, including packet-based networking have sparked a wave of changes with network implications. Application of these new technologies enables key business and technology benefits, including new service revenues, improved customer management, and operating expense savings.

Migration towards packet-based networks has been a dominant trend in the industry. The changeover has been evolutionary with the access network to the subscribers receiving the bulk of the initial attention. Now attention is being focused on optimization of transport networks for multiservice delivery. These transport networks have historically consisted of Synchronous Digital Hierarchical (SDH) Networks and Metro Area Networks (MAN).

This paper discusses the limitations of the legacy transport technologies in responding to the emerging service requirements. The concept of a Packet Transport Network (PTN) is introduced along with a description of how a PTN could help service providers respond to its growing challenges and to seize the convergence opportunity.

Challenges of Legacy Technologies in the New Era

The Growing Packet Transport Service Requirement

Due to improved price and performance and improved ease of use and management, the telecommunications industry has witnessed a surge in the deployment of packet based optical transport systems (P-OTS) or Packet Transport Networks (PTN). Other driving forces include:

⇒ Overall lure and momentum of Ethernet adoption. Ethernet has become the access technology of choice

⇒ Rapid recent growth in enterprise wide-area network (WAN) traffic which is driven by bandwidth intensive activities like video conferencing, data center expansion, server centralization, and virtualization

⇒ Triple play or "blended services" with high quality of experience

⇒ New applications with new requirements – bandwidth intensive, high performance/ Quality of Service (QoS), scalability, reliability, and security

⇒ Operator network migrations and convergence for improved Operating Expenses (OPEX), service delivery and management

The PTN market will continue to grow in the foreseeable future as shown in the figure below.

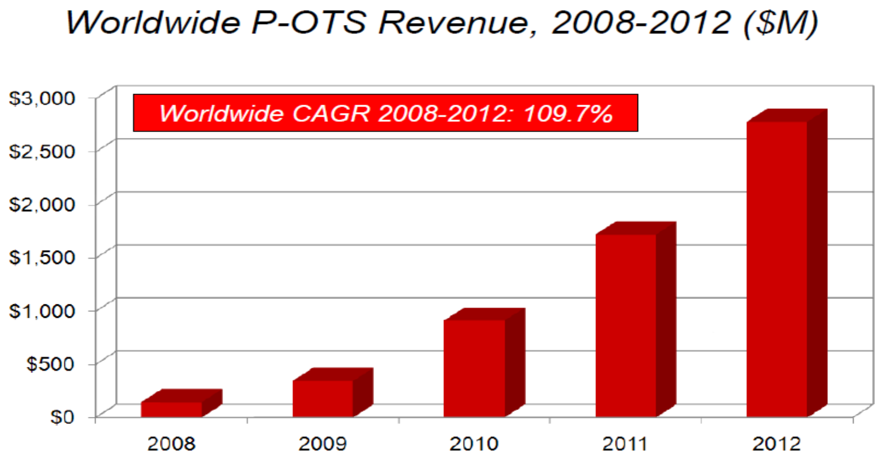

Figure 1: PTN Market (Source: Heavy Reading)

Characteristics of Next-Generation Transport Network

As Carrier-class Ethernet services are reaching wide spread deployment, a consensus is being reached that transport networks need an evolution towards packet-based networking. However, with a confusing number of solutions in the marketplace deployment has been slow. These solutions include NG-SDH with GFP/VCAT/LCAS, IP Routers with MPLS, T-MPLS and MPLS-TP.

Before we evaluate different approaches, let's check what makes an Ethernet service "Carrier-class" and the necessary requirements of a next-generation transport network.

A Carrier-class Ethernet service should have the following characteristics:

⇒ **End-to-End QoS**

Carrier Ethernet enables service providers to deliver CIR (Committed Information Rate) and PIR (Peak Information Rate) to each traffic flow that is classified physically (based on interface) or logically (based on customer VLAN or application type) and guarantees the lowest latency and jitter for delay-sensitive traffic. This level of QoS is close to that of an SDH private line and has better support for data traffic because of a PIR which allows subscribers to burst their traffic at the rate as high as wire speed. Carrier Ethernet also has an effective way of handling congestion in the network in order to maintain CIR for traffic flow under congestion. Finally, Carrier Ethernet uses Multiprotocol Label Switching (MPLS) to achieve better traffic engineering.

⇒ **Sub-50ms Protection**

One of the key advantages of SDH is its strong protection mechanism. Carrier Ethernet achieves sub-50ms protection by implementing MPLS Fast Reroute in hardware and it does not use software mechanisms for the convergence of the network. Another advantage of this protection mechanism is that it works in any topology, not just on a ring. Spanning Tree Protocol or routing protocols, such as OSPF, involve software implementations and their convergence time is far more than 50ms and is not deterministic.

⇒ **Ethernet Operations Administration and Management (OAM)**

Originally, Ethernet had no OAM capabilities. This was acceptable for a LAN but not for a MAN that spans a large area and supports a large number of users. In a MAN, troubleshooting is more difficult and OAM becomes a necessity. There has been significant progress made towards defining Ethernet OAM in the IEEE 802.3 Working Group and Metro Ethernet Forum. Some vendors have already implemented pre-standard OAM functions into their products such as Ethernet loop-back, Bit Error detection, Service Level measurements, and alarms for critical problems.

⇒ **<u>Scalability</u>**

Enterprise-class Ethernet has inherent limitations on scalability when used as a public network. These limitations include: the number of VLANs per network, the number of MAC addresses that can be learned and stored in the device, and the long and non-deterministic convergence time of the Spanning Tree Protocol (STP). The use of MPLS in Carrier Ethernet applications enables carriers to address the scalability of the network and to address the addition of the services such as Enterprise LANs.

⇒ **<u>Security</u>**

Surveys show that security is the top consideration for enterprise users when they choose network service providers. The cost effectiveness of an Ethernet service cannot be at the cost of security. Enterprise users are expecting the same security level as in SDH, Asynchronous Transfer Mode (ATM) or Frame Relay networks.

To provide a Carrier-class Ethernet service, as well as other revenue-generating services, the Next-generation transport network should have the following characteristics:

⇒ **Packet Based & Connection Oriented** – Relentless transition to packet based networks

⇒ **High Scalability** – The network is expected to last decades and serve an ever increasing number of users

⇒ **Strong security** – Customers must be confident about the security of their data

⇒ **Transparent Multi-service Support** - Time Division Multiplexing (TDM) services are still the bread and butter for many service providers and must be supported transparently on the network. The advantage is that the new network will be able to carry other applications to lower the costs for these legacy applications.

⇒ **High availability & Sub-50ms Protection** - The convergence time is considered as a crucial factor in a carrier-class network

⇒ **End to End QoS** – Predictable latency, low error rate and deterministic service delivery. In addition service providers want to maintain the same QoS level as in the traditional TDM/ATM networks while gaining the simplicity and the lower costs of Carrier Ethernet

⇒ **Simple Management & Low Total Cost of Ownership (TCO)** – Reuse as much as possible the existing network facilities and the supporting personnel skills/expertise

⇒ **Enhanced OAM** - A transport network can guarantee high quality traffic transmission only if it has an efficient OAM mechanism

⇒ **Standards-based and Interoperability** – Enabling an effective multi-vendor and multi-operator environment.

With the understanding of the definition for “Carrier-class” and “Next-generation transport”, we can move to a discussion of the various approaches to a next-gen transport network.

Evolution of Transport Networks

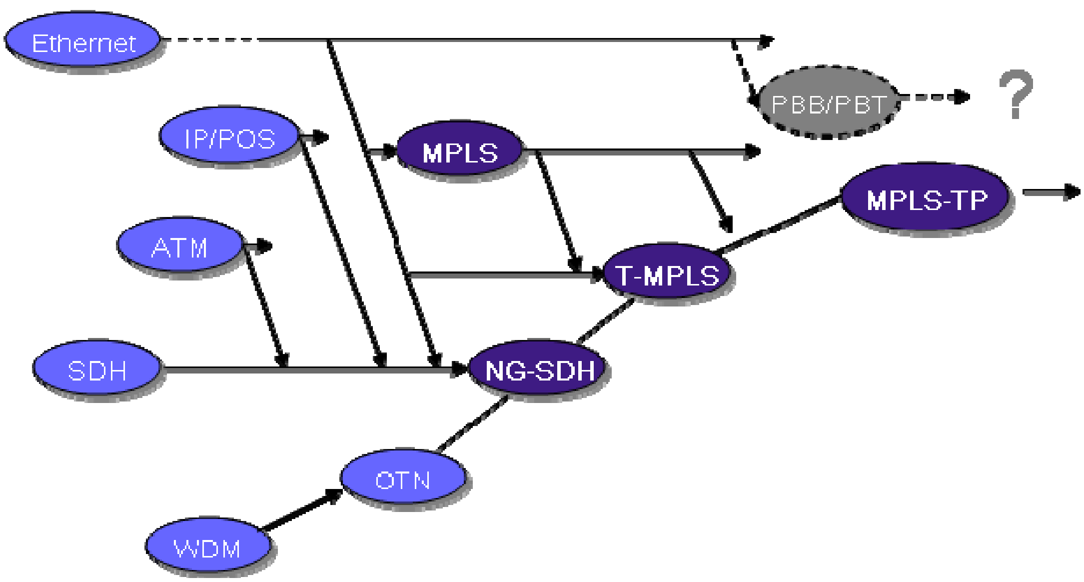

Figure 2: Evolution of the Transport Networks

SDH/NG-SDH Approach

SDH technology has been an essential part of transport networks for the past decade. Today, most transport networks are SDH-based. One approach to implementing carrier-class Ethernet is to take advantage of the existing SDH infrastructure and add new access devices or interface cards that can encapsulate Ethernet frames in appropriate SDH payloads and transmit the Ethernet traffic to the other end. This solution is called Next Generation SDH (NG-SDH). The three essential building blocks of an NG-SDH system are Generic Framing Procedure (GFP), Virtual Concatenation (VCAT), and Link Capacity Adjustment Scheme (LCAS).

GFP is an ITU-T standard that provides a framing procedure for packet services (GFP-F or framed based GFP) and storage services (GFP-T or transparent GFP). This permits transmission of non-native payloads over the SDH network.

Using VCAT, data traffic is carried in a number of parallel small-payload containers that are individually transported through the network and reassembled at their destination. Each channel within a Virtual Concatenation Group (VCG) may be on different paths. Flexible bandwidth allocation is achieved by choosing the appropriate number and size of payload containers. VCAT improves the efficiency of transporting data service compared to a fixed bandwidth SDH virtual container.

LCAS is an ITU-standard signaling scheme that allows two endpoints of a VC channel to dynamically tune the bandwidth at the request of the network management system without disturbing traffic. One common misconception is that LCAS allows SDH to tune a VCAT channel automatically according to the traffic rate. But in fact the network management system needs to send a command to the source node to add/delete a sub-channel to/from the existing VCAT channel. The source node uses LCAS commands to notify the destination node of the addition/deletion of the sub-channel.

Many service providers with a large installed base of SDH believe that they can offer Ethernet services whenever and wherever the demand originates. This service is simply an SDH channel with Ethernet access interfaces to subscribers using GFP mapping. With VCAT, service providers can allocate the "right sized" bandwidth according to customer's requirements. Plus, LCAS provides protection to VCAT groups on top of the native SDH protection. All of this sounds very promising, but service providers need to understand the lack of efficiency of NG-SDH in providing data services.

The inefficiency of NG-SDH in supporting data services lies in two areas:

⇒ **Inflexible bandwidth allocation**

The bandwidth allocation for an Ethernet service in a NG-SDH network must be an integral factor of VC-12/VC-3/VC-4. A further restriction is that the members in the VCG must be the same size.

For example, if a customer starts with 100Mbps service using a VC-12-46v container, but later wants to upgrade bandwidth to 1000Mbps (by using VC-4-7v) , service would be disturbed because the operator of that network would be required to recreate the route. This results in service interruption since the low order circuit must be deleted and the high order circuit must added.

⇒ **Bandwidth overbooking for QoS**

The Service-Level-Agreement (SLA) usually defines the bandwidth, delay, delay variation, and packet drop rules. To guarantee the bandwidth, a service provider would have to provision an Ethernet over SDH circuit, virtually concatenated or not, taking into account the peak rates of the bursty services it sells to its customers. Data traffic is inherently bursty and peak rates of multiple traffic flows usually do not occur at the same time. Therefore, the actual average utilization on each of these SDH circuits is usually a fraction of that peak rate, which makes the overall utilization of the network low.

For example, a STM-16 ring can support up to two Gigabit Ethernet (GE) connections using VCAT. By contrast, Ethernet service providers feel very comfortable using a single GE ring to support two GE customers because they know that the heaviest traffic from both customers is rarely simultaneous, and both customers will perceive a maximum rate of 1Gbps. Even when bursty traffic does occur simultaneously, Ethernet can use flow control and traffic shaping functions to avoid packet loss. Finally the cost of a GE ring is substantially cheaper than an STM-16 ring.

IP/MPLS Approach

MPLS was originally developed by the Internet Engineering Task Force (IETF) in order to address core IP router performance issues. However MPLS has since found strong application in service providers' converged core networks, and as a platform for data services such as IP-VPN.

MPLS is essentially a labeling system designed to accommodate multiple protocols. Label Switch Paths (LSPs) are used to define the paths of packets in the network so that a connection-oriented mode is introduced into a connectionless network. The use of MPLS labels enables routers to avoid the processing overhead of delving deeply into each data packet and performing complex route lookup operations based upon IP addresses.

MPLS technology provides customers with a versatile solution that significantly helps address the problems faced by present networks:

⇒ Speed

⇒ Scalability

⇒ Quality of Service and Class of Service management

⇒ Traffic engineering

⇒ Convergence of voice, video and data

MPLS has emerged as an elegant solution to meet the bandwidth and service management requirements for next generation IP based backbone networks. MPLS tackles the issues related to scalability and routing and it can be layered over a customer’s existing ATM and Frame Relay networks.

MPLS enhances a customer’s network by providing:

⇒ High speed data forwarding between customer sites

⇒ The ability to create a partially- or fully-meshed network, often described as any-to-any, with only a single physical and logical connection per site

⇒ Reservation of bandwidth for applications, and prioritization capabilities

MPLS allows the network to transmit data packets using standard IP routing protocols from any location to any location via a short predetermined path across the network. MPLS combines the most desirable features of Layer 2 and Layer 3 networks by providing the speed and efficiency of a Layer 3 network coupled with the security and reliability of a Layer 2 network.

A key capability provided by an MPLS network is Class of Service (CoS). CoS allows the optional definition of bandwidth requirements and traffic prioritization by application. By making the network aware of the applications traversing it, the traffic can be managed in a way that is appropriate for each traffic (application) type. CoS for each traffic type can be indicated in several ways at the time the traffic enters the network.

With the MPLS Fast ReRoute (FRR) function, an MPLS network can implement protection switching within 50ms.

IP/MPLS technology is mature enough for various application scenarios. What prevents it from being the perfect candidate technology in building a next-generation transport network?

⇒ IP/MPLS technology is quite complicated, and IP/MPLS routers are quite expensive.

⇒ For some transport network applications, such as mobile backhaul, all services are transported from base stations (Node B) to a central (RNC), so no complicated routing is needed. Since traffic patterns are relatively static, the powerful routing functions of IP/MPLS are wasted.

⇒ Since most transport networks have been SDH-based, maintenance staffs are quite accustomed to SDH operation and maintenance procedures. IP/MPLS network planning, operating and maintenance represent a major learning curve for the service provider's staff increasing the total cost of ownership.

⇒ IP/MPLS lacks the OAM functions necessary for managing carrier class services.

T-MPLS Approach

With packet networking on the rise, the ITU-T became interested in adapting MPLS to make it a "carrier class", according to recognized ITU-T architectural principles. The result is Transport MPLS (T-MPLS), a connection-oriented packet transport network based on MPLS that provides managed point-to-point connections to different client layer networks (such as Ethernet).

T-MPLS, as a new formulation of MPLS, was designed specifically for application in transport networks. It builds upon well-known and widely deployed IP/MPLS technology and standards, but offered a simpler implementation, where features not relevant to connection-oriented applications are removed and critical transport functionality gaps are addressed.

T-MPLS has been under development by the ITU-T since February 2006. T-MPLS uses the same architectural principles of layered networking that are used in other technologies like SDH and Optical Transport Network (OTN). Service providers have already developed management processes and work procedures based on these principles.

In this way T-MPLS provides a reliable packet-based technology that is familiar and also aligned with circuit-based transport networking. Thus it supports current organizational processes and large-scale work procedures.

In addition, the key enhancements to MPLS provided by T-MPLS, such as engineered point-to-point bi-directional LSPs, end-to-end LSP protection, and advanced OAM support allow optimal control of transport network resources leading to lower operational expenses.

However, unlike MPLS, T-MPLS does not support a connectionless mode and is intended to be simpler in scope, less complex in operation and easily managed. Layer 3 features have been eliminated and the control plane uses a minimum of IP mechanisms leading to equipment implementations that support service providers' needs for lower-cost, high-volume packet networking in their next-generation architectures.

T-MPLS is formulated in conjunction with today's circuit-based transport networks, following the same architectural, management and operational models. It is thus intended to provide an optimum evolution path for many service providers in their metro and access networks, as they transition to a packet-based future.

T-MPLS = MPLS + OAM – L3 Complexity

Another way to view T-MPLS is to think of it as a strictly connection-oriented subset of MPLS:

⇒ Survivability is specific to the transport network. T-MPLS defines its protection capability using ITU-T's Recommendations G.8131/Y.1382 (T-MPLS linear protection switching with 1+1, 1:1 and 1:N options) and G.8132/Y.1383 (T-MPLS ring protection switching). MPLS Fast ReRoute (FRR) capability requires the use of LSP Merge that is excluded from T-MPLS. Since no control plane is involved, protection switching performance can be very fast.

⇒ OAM is specific to the transport network and functionality is referenced from ITU-T's Y.1711 (OAM mechanism for MPLS networks). This provides the same OAM concepts and methods (e.g. connectivity verification, alarm suppression, remote defect indication) already available in other transport networks, without requiring complex IP data plane capabilities.

⇒ The T-MPLS control plane (specific for the transport network) is currently null. In other words, the management plane will be used for manual/automated provisioning, in the same way as SDH and OTN networks are provisioned today. However, as is the case for other transport network technologies, the control plane for T-MPLS is envisaged to be ASON/GMPLS and will thus enable more dynamic and intelligent operation.

⇒ No label reservation. T-MPLS will not reserve labels for its own use independently of MPLS. Any requirements for special label assignment will be handled by the IETF and coordinated with the MPLS standards. This helps to ensure that interoperability and interworking will be readily achievable.

Differences of T-MPLS from MPLS

In order to define a subset of MPLS that is connection-oriented and that lends itself to the established transport OAM model, several MPLS protocol features have been excluded from T-MPLS. Key differences of T-MPLS compared with MPLS include:

⇒ Use of bi-directional LSPs. While MPLS LSPs are uni-directional, transport networks traditionally provision bi-directional connections. T-MPLS therefore pairs the forward and backward LSPs to follow the same nodes and links.

⇒ No PHP (Penultimate Hop Popping) option. PHP, by removing the MPLS label one node before the egress node, simplifies the egress processing required. Indeed, it comes from a historical legacy of wanting to minimize router processing requirements. However, the interface now has a mix of IP and MPLS packets and the final node must perform an IP (or other payload) look-up instead. More importantly, OAM is more complex or even impossible since the MPLS label context is lost.

⇒ No LSP Merging option. LSP Merge means that all traffic forwarded along the same path to the same destination may use the same MPLS label. While this may promote scalability, in fact it makes effective OAM and Performance Monitoring (PM) difficult or even impossible, since the traffic source becomes ambiguous and unknown. It is thus not a connection-oriented concept.

⇒ No ECMP (Equal Cost Multiple Path) option. ECMP allows traffic within one LSP to be routed along multiple network paths. Not only does this require additional IP header processing, as well as MPLS label processing, but it makes OAM more complex since Continuity Check (CC) and PM flows may follow different paths. This concept is not needed in a connection-oriented network.

MPLS-TP based Packet Transport Networks

After IETF raised concerns over T-MPLS technology, mainly about incompatibility with the already established IP/MPLS, the ITU-T and the IETF started a joint activity to solve potential issues. The decision was to transfer control to IETF to develop an MPLS Transport Profile (MPLS-TP) with input from ITU recommendations. A new activity was added to the charter of the MPLS working group of IETF.

Introduction to MPLS-TP

MPLS-TP is a profile of MPLS whose definition has been turned over to the IETF. It will be designed for use as a network layer technology in transport networks. Its design will be a continuation of the work started by the transport network experts of the ITU-T, specifically SG15, as T-MPLS with the required protocol extensions to MPLS being specified by the IETF. It will be a connection-oriented packet-switched application. It will offer a dedicated MPLS implementation by removing features that are not relevant to connection-oriented applications and adding mechanisms that provide support of critical transport functionality.

MPLS-TP is based on the same architectural principles of layered networking that are used in longstanding transport network technologies like SDH and OTN. Service providers have already developed management processes and work procedures based on these principles.

MPLS-TP will provide service providers with a reliable packet-based technology that is based upon circuit-based transport networking, and thus is expected to align with current organizational processes and large-scale work procedures similar to other packet transport technologies.

MPLS-TP is expected to be a low cost L2 technology that will provide QoS, end-to-end OAM and protection switching.

In February 2008 the ITU-T and IETF agreed to work jointly on the design of MPLS-TP. Based on this agreement MPLS-TP will be specified in a number of RFCs. The ITU-T recommendations will refer to these RFCs.

The following IETF RFC drafts exist for MPLS-TP:

⇒ draft-jenkins-mpls-mplstp-requirements - MPLS-TP Requirements

⇒ draft-sprecher-mpls-tp-oam-analysis - MPLS-TP OAM Analysis

⇒ draft-vigoureux-mpls-tp-oam-requirements - Requirements for OAM in MPLS Transport Networks

⇒ draft-vigoureux-mpls-tp-gal - Assignment of the Generic Associated Channel Header Label (GAL)

⇒ draft-blb-mpls-tp-framework - A Framework for MPLS in Transport Networks

⇒ draft-andersson-mpls-tp-oam-def - "The OAM Acronym Soup"

⇒ draft-bocci-pwe3-mpls-tp-ge-ach - MPLS Generic Associated Channel

⇒ draft-gray-mpls-tp-nm-req - MPLS TP Network Management Requirements

⇒ draft-sprecher-mpls-tp-survive-fwk - MPLS TP Survivability Framework

Benefits of MPLS-TP based PTN

The MPLS-TP technology uses the data plane of MPLS and has simplified the complicated application scenarios of MPLS. It decreases equipment, operation, and maintenance cost. The data plane is separated from the control plane. This leads to higher network stability, reliability and flexibility. With a strong OAM and protection switching function, the MPLS-TP based PTN could achieve the same reliability and resilience level as SDH/NG-SDH.

Compared with the widely deployed SDH/NG-SDH based networks, the MPLS-TP based PTN is an evolutionary step.

⇒ Operational methodology is similar, if not the same, as an SDH network. This is particularly important for large service providers who may have an extensive automated provisioning and control system developed over many years. A large impact on staff training and skill set can also be avoided.

⇒ The management network utilizes the familiar transport style processes:

- Provision what you want
- Retrieve performance reports periodically or instantly
- Retrieve alert from alarms if a fault occurs
- Easily locate faults using determined, cleared Defect-Alarm relationships

⇒ The extension to packet networking complements the existing transport plane.

⇒ The GMPLS control plane is similar to SDH and OTN and is also aligned with existing management models.

⇒ Packet based networking provides higher bandwidth efficiency over circuit based networking. This is especially true with data traffic growing and becoming dominant.

Compared with IP/MPLS based networks, the MPLS-TP based PTN provides the following advantages:

⇒ By focusing on the transport domain, rather than attempting to also cover routing applications, MPLS-TP is a simpler approach than an equivalent IP/MPLS-based approach. Once again, this should avoid a large impact on staff training, skill set and network complexity

⇒ TCO that is lower than IP/MPLS since it omits IP-oriented routing and control complexity

⇒ MPLS-TP supports OAM & protection/redundancy in each layer

⇒ Connection-oriented approach with traditional protection schemes and transport-centric OAM tools that line up with established architectures

⇒ Guaranteed transport performance and QoS for every kind of supported client service

⇒ Designed from the start for transport network, MPLS-TP based equipment provide a complete synchronization solution, guaranteeing 3G timing accuracy

Some specific technical features of MPLS-TP, which are useful for packet transport networks, are listed below.

Bi-directional Congruent LSP

This allows MPLS-TP based networks to emulate classical transport network – transmit and receive follow the same path through the network. It simplifies the operations for bi-directional connectivity. This also improves jitter performance since the packet delay variance is reduced. Troubleshooting is also simplified and improved using the OAM enhancements provided by MPLS-TP.

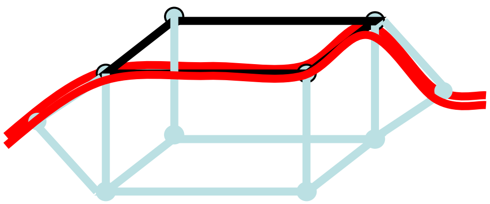

Figure 3 - Bi-directional Congruent LSP

No LSP Merge

IP/MPLS based architectures allow LSP merge which results in loss of LSP head-end information. This information is critical to provide enhanced OAM capabilities desired by service providers. MPLS-TP does not allow LSP merges leading to enhanced end-to-end OAM capability.

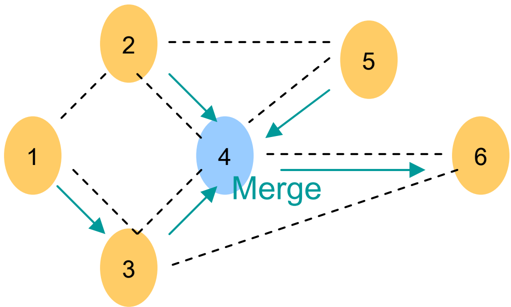

Figure 4 – LSP Merge

No Penultimate Hop Popping (PHP)

Popping of the outer MPLS label, allowed in IP/MPLS based networks, causes the loss of context at the adjacent P-router. Since the outer MPLS label is used as the OAM identifier (packet context) for the enhanced OAM capabilities offered by MPLS-TP, this is not allowed in MPLS-TP networks. Also, PHP does not offer any apparent benefits for Layer-2 VPNs.

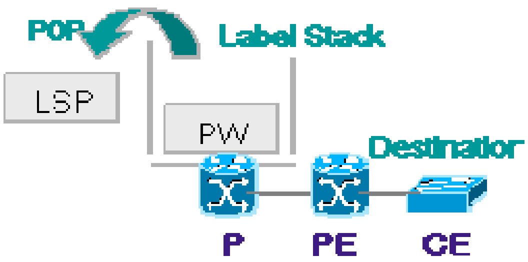

Figure 5 – Penultimate Hop Popping

No Load Balancing

As discussed in previous sections, MPLS-TP supports bi-directional, congruent LSPs for transporting any kind of traffic and does not allow LSP merging. Thus, there is only one pre-determined end-to-end path for reaching destination at a given hop. This provides a very deterministic traffic pattern and allows service providers more confidence in guaranteeing SLAs as well as better traffic monitoring capabilities.

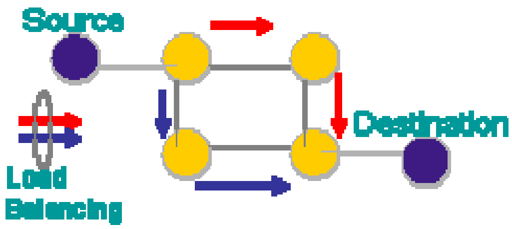

Figure 6 – Load Balancing

Business case for MPLS-TP

MPLS-TP based PTN deployment not only provides reduction in capital and operational expenses for the service providers, but, at the same time, acts as a significant revenue driver also by offering high ARPU services with guaranteed SLAs.

The following figure depicts savings for a hypothetical metro network designed for a mid-size city with over 600G capacity.

		Advantage
CAPEX Savings:		
Lower Investment	• Significant savings over MSTP/MSPP – savings based on a metro-network built for mid-size city with over 600G capacity	20%
Revenue Drivers:		
Bandwidth Efficiency	• Flexible data-pipes enabling the end-users to save by subscribing the service in smaller chunks and as their demand goes up, they can ask for higher data rates	15%
MEF Certification	• MEF 9 and MEF 14 certification • Offers E-Line, E-LAN, and E-TREE services enabling the support of high-ARPU L2 VPN services	15%
OPEX Savings:		
Enhanced OAM	• Much easier troubleshooting compared to IP/MPLS • Simplified network provisioning	5%
Low Power	• Lower power consumption compared to MSPP/MPLS platforms	51%
Smaller footprint	• Higher switching capacity per RU compared to MSPP/MPLS platforms • Smaller footprints bring added real-estate advantage	68%

Figure 7: Business Case for MPLS-TP

Summary

MPLS-TP based PTNs take advantage of the cost-effectiveness and ease-of-use of pseudo wire over IP/MPLS architecture, and adds carrier-class feature such as traffic engineering, QoS, and connection oriented provisioning. It allows network operators to migrate all their transport services to a converged MPLS-TP core network. This allows service providers to realize more revenue by rapidly introducing new services, while reducing OPEX and CAPEX.

With MPLS-TP based PTN, service providers will enjoy all of the following benefits:

- ⇒ Carrier-grade, multi-vendor, ITU-T standardized, common packet transport network
- ⇒ Lower TCO
- ⇒ Packet based networking with statistical multiplexing to improve bandwidth efficiency and flexibility
- ⇒ Fully integrated IP and transport platform for next-generation common access and transport solution
- ⇒ Seamless interworking with the IP/MPLS core.
- ⇒ Comprehensive support for multi-service interfaces to converge IP and traditional technologies like ATM, TDM
- ⇒ Support for end to end QoS, strict Committed Information Rate (CIR), guaranteed frame delay, frame delay variation (Jitter) and packet loss ratio
- ⇒ Capability to obtain different performance characteristics for key applications without requiring the use and expense of multiple networks.
- ⇒ Comprehensive OAM including MPLS/PW/Eth/TDM/ATM OAM
- ⇒ Support for sub 50ms protection switching ensuring high availability
- ⇒ Ability to interconnect virtually any combination of endpoints in a simple and flexible manner
- ⇒ High performance timing synchronization & distribution network to meet 3G mobile requirement

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About UTStarcom, Inc.
UTStarcom is a global leader in IP-based, end-to-end networking solutions and international service and support. The company sells its broadband, wireless, and handset solutions to operators in both emerging and established telecommunications markets around the world. UTStarcom enables its customers to rapidly deploy revenue-generating access services using their existing infrastructure, while providing a migration path to cost-efficient, end-to-end IP networks. Founded in 1991 and headquartered in Alameda, California, the company has research and design operations in the United States, China, Korea and India. UTStarcom is a FORTUNE 1000 company. For more information about UTStarcom, visit the company's Web site at www.utstar.com

CP-WP-MPLS-TP PTN-1109