Stay one step ahead

MPLS-TP:

Benefits of MPLS-TP Usage in Mobile Backhaul Networks

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1. Introduction

In the last few years mobile operators have been faced with tough decisions regarding their network evolution, both for radio and backhaul transport. The introduction of the Blackberry PDA, the explosion of the iPhone and similar technology in the Smartphone arena has created an enormous strain on mobile backhaul networks. A growing number of cellular users are using broadband applications such as e-mail, SMS, YouTube, Facebook and various live video applications. All new applications are IP based and the bandwidth requirement far exceeds any previously required.

Mobile operators have already accepted the fact that the transport backhaul network will have to evolve in order to meet new demands. There is already a common understanding that the evolution will carry the Mobile Backhaul (MBH) network, moving in time, towards IP based transport. When planning such evolution and its migration, cellular operators are faced with a number of challenges that need to be solved in a holistic approach and include:

- **Scalability**
  The ability to serve more customers with higher demands for longer network duration
- **Multiservice Support**
  The existing MBH network carries various services utilizing different physical interface and transport means. Any evolution must be able to handle and integrate the services and interfaces into the new scheme.
- **High Availability and End-to-End QoS**
  Cellular equipment and connections have stringent requirements on recovery convergence and synchronization which have to be taken into account
- **OAM and Network Manageability**
  In order to improve and keep high QoS, applicable OAM and management tools must be part of any new scheme
- **Standardization and Interoperability**
  As parts of the mobile network have already evolved, the new MBH evolution must be based on standards that allow full interoperability with existing parts
- **Lower Total Cost of Ownership**

The advantages brought by MPLS to the general IP transport world, such as the connection oriented approach, are well known and its advanced standardization level makes it a leading candidate for MBH evolution.
However the question remains – can IP/MPLS provide solid answers for all the above challenges?

This document will try and answer the question and highlight the advantages that usage of MPLS-TP can bring to a mobile operator when using it in its RAN MBH network evolution.

2. What is MPLS-TP?

2.1. General

MPLS was originally developed by the Internet Engineering Task Force (IETF) in order to add a connection oriented methodology to the IP traffic in full mesh topology. The notion of Label Switched Path (LSP) was introduced to define connection-oriented paths for packets in a connectionless network. MPLS has emerged as an elegant solution to meet the bandwidth; service management and additional requirements for next generation IP based backbone networks. MPLS tackles the issues related to scalability and routing and can be layered over a customer's existing transport technology connecting IP routers. 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. Coupled with its Traffic engineering (TE) capabilities and Fast Reroute (FRR) protection mechanism MPLS became the de-facto standard in the network core whether it is for mobile or fixed line.

When fixed and cellular operators started to look at extending MPLS from the core into their transport networks, they found out that MPLS lacked some fundamental features and attributes required for carrier class transport. The aspects preventing wide spread acceptance of MPLS in the MBH transport network are:

- IP/MPLS technology is relatively complicated, and supporting routers are expensive
- In MBH the traffic patterns are relatively static – from BTS/NodeB to BSC/RNC – full mesh capabilities and complicated routing are not required
- Maintenance and planning personnel are accustomed to SDH operation and maintenance procedures. IP/MPLS network planning, operating and maintenance represent a major learning curve for the service provider's employees increasing the total cost of ownership
- IP/MPLS lacks the OAM functions necessary for managing and monitoring the requirements of MBH network

2.2. MPLS-TP Standardization Status

The first attempt to improve IP/MPLS qualities towards transport Carrier Class capabilities was done by ITU-T with T-MPLS. This effort has now been replaced by the joint IETF and ITU-T task force in defining a Transport Profile for MPLS.

As its name implies MPLS-TP is an extension of IP/MPLS. The MPLS-TP proposal contains a set of compatible technological enhancements made to the existing MPLS standards. This extends the definition of MPLS to include the support of traditional transport operational models. This proposal adopts all of the supporting QoS mechanisms already defined within the standards, and also brings the benefits of path-based, in-band OAM and protection mechanisms found in traditional transport technologies.

2.3. How does MPLS-TP Differ from IP/MPLS

The difference between IP/MPLS and MPLS-TP is in network and services architectural approaches.

IP/MPLS presumes operation in a full mesh network with IP services where each network element participates in packet routing and consequently must be capable of routing all services in the network. However, this model requires high throughput and scalability which increases overall equipment cost.

MPLS-TP is based on a transport network model. The network elements are interconnected by transport 'pipes' and all services pass through these 'pipes' using simplified Pseudo Wire Emulation (PWE) encapsulation. This concept simplifies the equipment's requirements in certain aspects, thereby lowering its cost.

Although PWE capabilities exist in IP/MPLS MPLS, the significance of adding transport-like features, taken from SDH, makes the concept of MPLS-TP more Carrier Class.
To support its architectural concept, MPLS-TP differs from IP/MPLS in the following aspects:

- **Bi-directional Congruent LSP** - instead of two detached unidirectional LSPs connecting the end points of a path
- **Removal of LSP merge to allow enhanced OAM** - by keeping the head-end information end-to-end
- **Removal of PHP**
- **Predetermined and deterministic paths** - managed by central Network Management System (NMS)
- **Creation of the Tandem Connection Monitoring (TCM) concept and support in MPLS** - which allows network segmentation to various domains
- **Augmenting the Fast Re-Route (FRR) protection mode**
  of IP/MPLS with multi-level protection modes as well as ring and path protection definitions similar to SDH.
- **Creation of deterministic LSPs and PW**
  by central management system and not only by a dynamic control plane

The combination of significantly lower cost and transport capabilities makes MPLS-TP the solution of choice for future fixed and mobile network equipment.

3. Benefits in using MPLS-TP in the MBH Network

One of the main reasons for the creation of MPLS-TP is to simplify the use of MPLS in networks that are not dominated by mesh topologies. The MBH last mile and middle mile networks are the predominant examples of such cases. It is not surprising to see that the use of MPLS-TP in these parts of the network can be beneficial to mobile operators when expanding IP/MPLS from the core to the RAN.

The following paragraphs elaborate on the benefits of using MPLS-TP in the mobile RAN.

3.1. The Benefit of Predictability

The use of bi-directional LSPs and PWs defined by a central NMS creates predictable and deterministic connections. Such predictability is highly required in networks susceptible to delay and delay variation changes that may affect QoS. The MBH network and particularly the path between BTS/NodeB and the BSC/RNC is such network.

The ability to set a deterministic path with known delay is an important aspect when planning Timing over Packet (ToP) mechanisms using Layer 2 based solutions such as IEEE1588v2. Using classic IP/MPLS, even with its traffic engineering capabilities, to find the most suitable path for timing packets cannot compare to the complicated path computation algorithms implemented by NMS systems at the network level.

3.2. The Benefit of using NMS and Control Plane

MPLS-TP defines an option for static provisioning by a central NMS. The use of NMS, which has all the information about the network status – elements, physical connections, bandwidth utilization, fault status – and robust path computation algorithms provide broader vision and allows for better planning and prediction of the outcome of every provisioned LSP.

The information gathered and stored in the NMS provides operators with an excellent database for network planning. The fact that bandwidth allocation on each network element and link is known, allows operators to pinpoint places in the network that require expansion. In addition the operator is able to plan the required maintenance and operational tasks ahead of time in a way that will minimize traffic interruptions.

Figure 1 depicts a generalized view of the network management concept that can be implemented in the MPLS-TP scheme

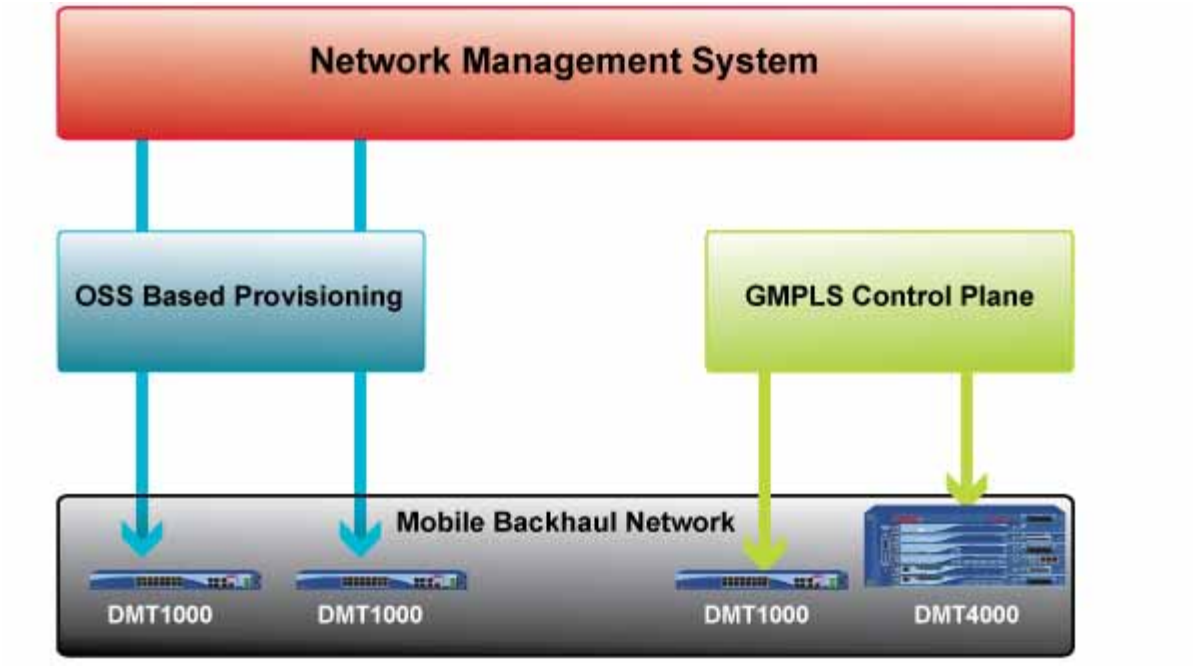

Figure 1 – Generalized View of MPLS-TM Management

The use of NMS does not totally eliminate the ability of the operator to use dynamic CP. CP provides some flexibility in cases of failure and the need for flexible recovery plans. MPLS-TP defines GMPLS as the CP of choice for MPLS-TP.

The GMPLS CP significantly simplifies network and services administration and provides advanced resiliency capabilities:

- **Unnumbered Interfaces Support**
  Only one IP address per node is required (opposed to IP/MPLS where each network interface requires unique IP address which causes to frequent misconfiguration problems and network connectivity drops)
- **Bidirectional LSPs**
  Allows complete service creation in one step (opposed to IP/MPLS where services are created in two steps requiring separate provisioning of each service side)
- **Advanced TE Techniques**
  SRLG, transit delay, path disjoint and other TE parameters supported in Constrain based TE path computation
- **CP initiated Notifications of Path Failure**
- **Advanced protection schemes**
  Support for:
  - Guaranteed Restoration
  - Protection and Restoration Combined
  - End-to-End Mesh Recovery

3.3. The Benefit of Enhanced OAM Mechanisms

Classical IP/MPLS networks lack extensive OAM especially Performance Monitoring (PM), tools and mechanisms. The existing mechanisms are not enough for a real transport network like the MBH.

MPLS-TP brings new concepts and mechanisms into IP/MPLS, without changing its nature, which are tried and proven for more than a decade in SDH and other transport protocols.

The newest architectural building block brought by MPLS-TP is Tandem Connection Monitoring (TCM). TCM allows segmentation of the network into different domains whilst monitoring the LSP and PW performance in each domain separately without losing the monitoring of the end-to-end path and service. The TCM concept which exists in SDH is important for mobile operators leasing part of their network from 3rd parties. With TCM they can now monitor the performance at the input and output of the 3rd party cloud for maintenance and conformity to SLA contracts.

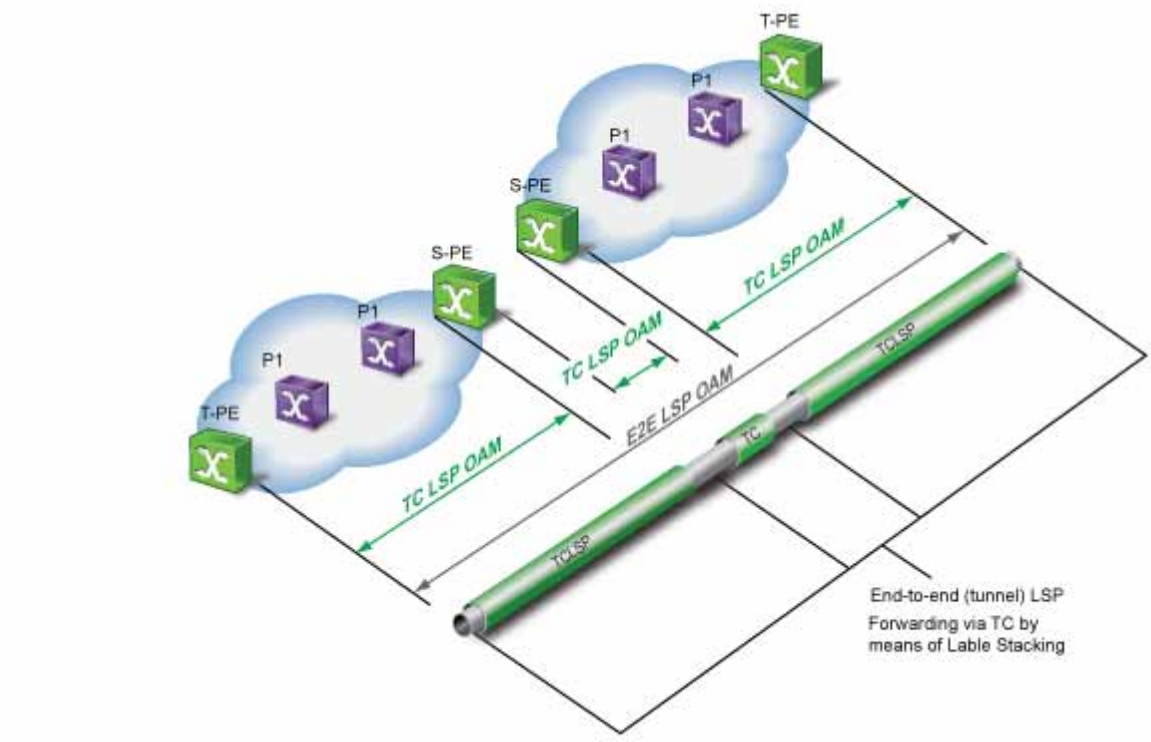

Figure 2: TCM Concept

The mixed use of Ethernet OAM (Y.1731, 802.1ag) and MPLS OAM (Y.1711) strengthens MPLS-TP OAM and provide operators with information such as LSP delay measurements, trace route information, packet loss and diagnostic test capabilities.

The information obtained through the new and existing monitoring mechanisms helps in the implementation of enhanced network and traffic resiliency which is an important part in MBH networks.

3.4. The benefit of Enhanced Resiliency

The existing IP/MPLS resiliency mechanisms are kept as part of the MPLS-TP scheme but mechanisms are added which do not require any IP routing involvements and are simpler, yet more deterministic in nature. Two new mechanisms, one for ring and the other from 1:1 or 1+1 linear protection, depicted in Figure 3, have been taken from the existing SDH world and ensure sub 50msec recovery from various faults indicated through the monitoring mechanisms.

Additionally FFR is augmented with new mechanisms such as Combined Protection and Restoration and End-to-End Mesh Recovery.

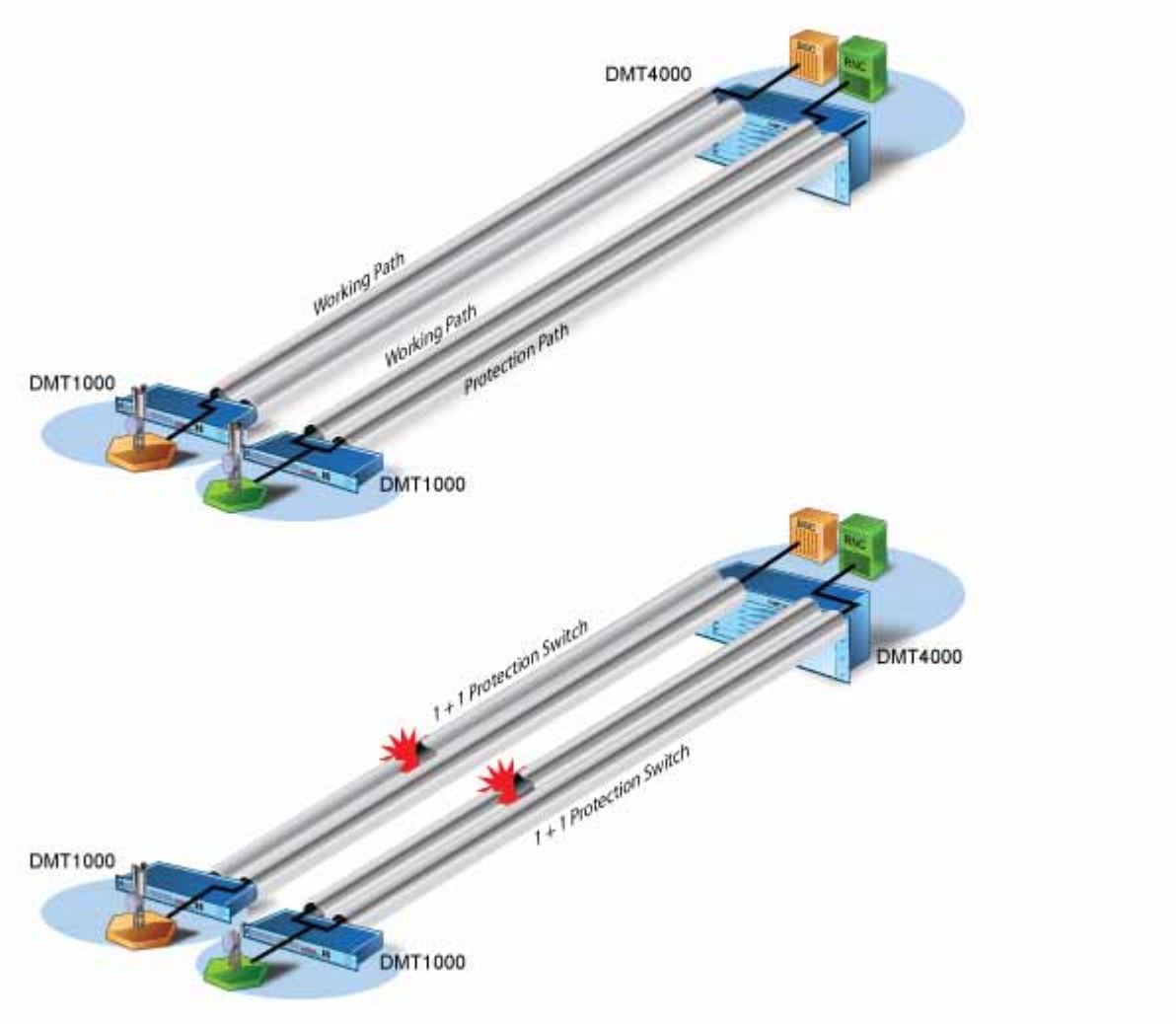

Figure 3 – MPLS-TP Linear Protection

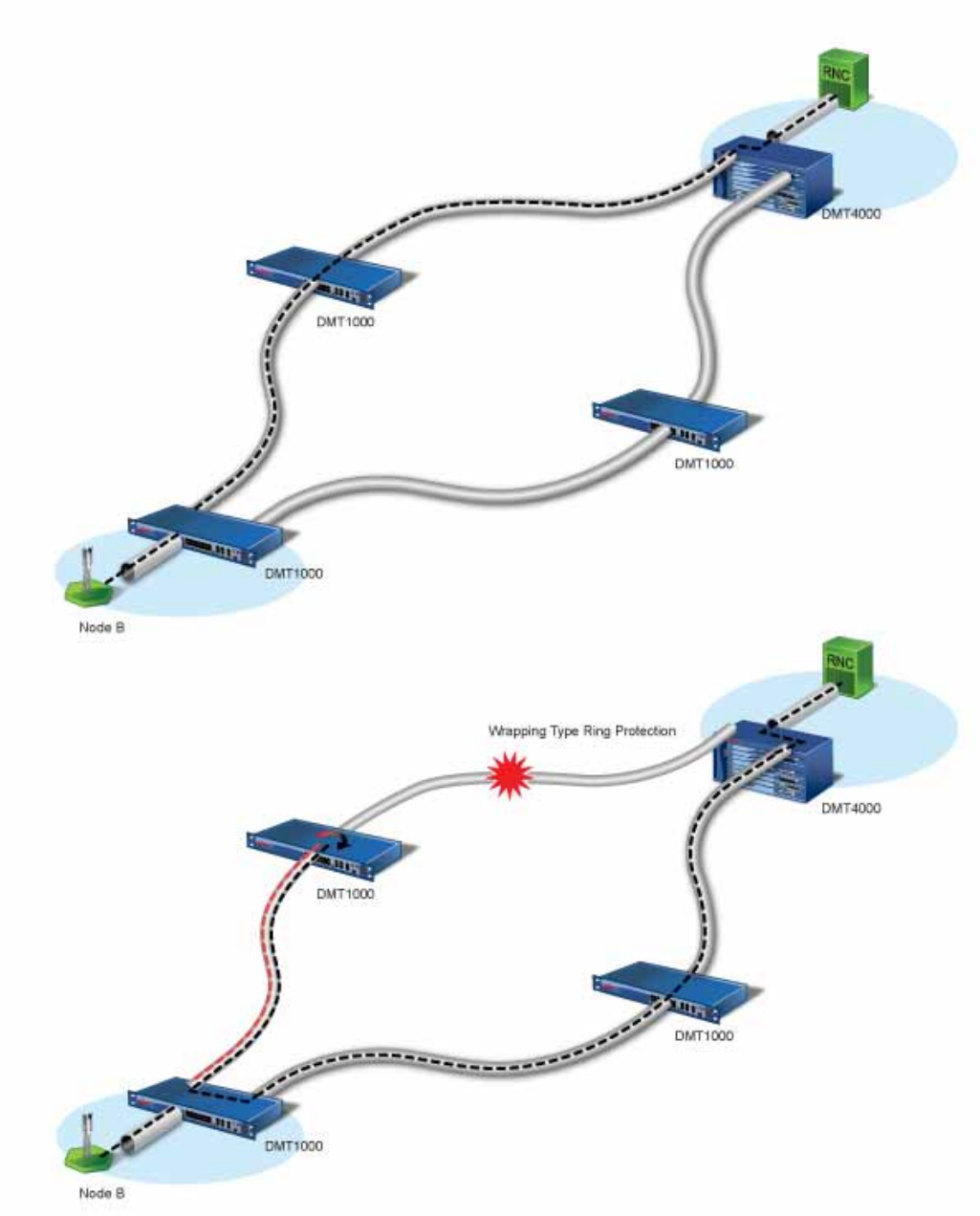

Figure 4 – MPLS-TP Ring Protection

3.5. MPLS-TP Affect of Total Cost of Ownership (TCO)

TCO encompasses all aspects of network creation or migration. TCO takes into account issues such as new equipment procurement, training existing and new personnel, creating or augmenting operational procedures, implementing new network planning and management schemes, etc. In a migration stage, where the operator already has personnel, procedures and equipment in place, maintaining low TCO is of utmost importance.

One of the benefits of the MBH network migration to MPLS-TP is the relatively low TCO required. The savings are evident in various aspects of TCO:

- **MPLS-TP Equipment is Much Lower in Cos**t for procurement - it eliminates the need for high processing power to support high capacity routing as network elements are based on Layer 2 architecture
- **Enhanced OAM and Resiliency Mechanisms** - supports faster reaction to network disrupting events, reducing maintenance time and cost
- **NMS Hides a Lot of the Network Complexity from the Users** - makes it easier to train SDH savvy planning and operational personnel with operating MPLS-TP networks
- **MPLS-TP is Based on IP/MPLS Foundations** - ensures full interoperability with existing network core. No mediation devices are required to connect an already migrated MPLS-TP network part to the existing IP/MPLS core

4. Summary

Benefits of MPLS-TP Usage in IP Based Backhaul Evolution

MPLS-TP represents a new development in the larger MPLS protocol suite. It offers evolution architecture for TDM-based transport networks, and is optimized to carry packets. It carefully preserves the OAM and management characteristics that transport groups have been using in the past and allows a full end-to-end integration with existing and future IP/MPLS infrastructures. By using IP/MPLS and MPLS-TP, service providers will have a consistent way of provisioning, troubleshooting, and managing their networks from edge to edge.

MPLS-TP is still worked out by the standardization joint task force, although parts of the standards suite are already in place.

Celtro's position is that the last mile and Middle Mile sections of the MBH network will migrate to a mixture of IP/MPLS and MPLS-TP. The selection between the two approaches will depend on the state of the network, the existing equipment and the level of technical personnel available to implement and operate the migrated network

Celtro is committed to implement all dynamic signaling IP/MPLS parts of the standards suite that will allow interoperability with existing core in all its DMT product portfolio relevant members.

As MPLS-TP standards are ratified, Celtro will implement them on top of the IP/MPLS foundation and DMSView, Celtro's management system. As part of the implementation, the operator will be able to select between a deployment based on IP/MPLS and MPLS-TP architectural deployment concepts.