How to support growing Ethernet traffic with the existing TDM, analogue, voice, low rate, low latency and synchro sensitive circuit transport … for power, transportation, industries, defense infrastructures or mobile backhaul …
or
How to optimize TDM/PDH/SDH and Ethernet in 10GE PTN with MPLS-TP

By Eric Piaget

Summary

Different applications like the electricity teleprotection, radar exchanges or simply some old generation RTUs/NTUs, SCADA and more… require high reliability of bandwidth, high stability, synchro and phase transport and low latency. These multiservice voice/data/status interfaces are digitalized, converted and groomed by TDM/PDH DACS multiplexer in E1/T1 to be transported by SDH/SONET network together with Ethernet over SDH/SONET (EoS).

These sensitive applications require generally small bandwidth and are easily transported by single STM1/OC3 or STM4/OC12 fibers. The SDH/SONET for many customers looks as the best secure transport for their activity through their own or leased infrastructure. They have difficulties to leave it without suspecting industrial risks.

But the IP/Ethernet internal traffic is growing everywhere with new applications of internal communication, video surveillance, Wi-fi/PMR distribution requesting standard constraints and also the new Ethernet for Process Control and SCADA that require high QoS, high stability and low latency and precise timing information.

The simple solution to keep the same level of service should be to increase SDH/SONET transport pipes to STM16/OC48, and then to STM64/OC192. This is a simple but costly solution, it is not necessary the best…

We are going to demonstrate the interest to mix TDM/PDH/SDH and Ethernet networks together with New Generation network "PTN" with "MPLS-TP" protocols and migrate step by step the applications to IP and move the transport from synchronous network SDH to packet transport networks PTN without service interruption.

This demonstration can not only be applied to a stable of infrastructure like the customers in energies, utilities, transportation, industries or defense infrastructures but also in high growing domains like mobile backhaul 2G/3G/LTE.

Loop Telecom and its Universal Solutions

Loop Telecom was founded in Taiwan by a group of established professionals from the communication industry. Since 1991 they have developed and produced multiservice TDM/PDH then SDH/SONET multiplexers and several IP/Ethernet solutions and now Loop Telecom produces new PTN with MPLS-TP and Carrier Ethernet solutions as standalone nodes or integrated inside multiservice TDM/PDH and SDH modular equipment with the same level of service.

Loop Telecom Modular **Universal Transport Network** (UTN) includes:

- the **O9400R-PTN** SDH/SONET multiplexer with PTN switch, MPLS-TP and Carrier Ethernet support or
- the **O9500R-PTN** hybrid Multiservice TDM/PDH and SDH/SONET multiplexer with PTN MPLS-TP/CE switch
- an optional CWDM or DWDM **OTN** multiplexer
- the **iNMS**, the single management platform for TDM/PDH, SDH/SONET, PTN MPLS-TP and OTN devices.

Definitions

TDM The Time Domain Multiplexing makes the conversion of multiservice applications as voice, analogue data, asynchronous and synchronous low rate, contact relay information… in digital information nx64kbps Time Slots or DS0 framing or unframed with E1, T1, E3, T3 interfaces cross-connected by DACS and transported over copper, fiber, microwave point to point or multiplexed by a SDH/SONET device.

PDH The Plesiochronous Digital Hierarchy is the old technology of communication between TDM nodes with similar clock. Now the TDM nodes are synchronized with the same clock and do not need the hierarchy. But the PDH name is often used to talk about TDM DS0 circuits and equipment.

SDH The Synchronous Digital Hierarchy (ETSI) makes the transport over fiber STM1/4/16/64/256 links of the TDM circuits, ATM circuits and Ethernet EoS within a hierarchy of transport using VCxx containers.
Main advantages of SDH are to carry independent circuits, with each independent synchronization, the absolute QoS because the bandwidth is permanently reserved in the pipe, the mechanism of protection in ring, bus or Mesh fiber infrastructures, and the end-to-end management of transmission quality.

SONET The Synchronous Optical Networking (ANSI) is the same technology and supports the same advantageas SDH but with ANSI definitions and transport over fiber with OC3/12/48/192/768 hierarchy.

PWE3 or **PW** The PseudoWire Emulation Edge-to-Edge is used to transport a service such as TDM (E1/T1/E3/DS3), SDH, ATM, Ethernet with VLAN, Q-in-Q, SAN…over Packet Switched Network (PSN): IP, Ethernet or MPLS. Different emulations are used like SAToP for unframed E1/T1/E3/T3, CESoPSN for framed TDM DS0 and CEP for channelized SDH/SONET at the VCx/VTx level.

PTN The New Generation “Packet Transport Network” combines the advantage of the SDH with the high capacity transport of the packet technology. This technology takes the packet switching network as the core of transport. PTN uses either Carrier Ethernet or MPLS as the transport encapsulation running over GE/10GE. Together with Ethernet Synchronous (SyncE) fibers and PTP 1588v2 timing technologies, PTN provides a high capability of statistical multiplexing for carrying the TDM (SDH/PDH), ATM, and Ethernet services in PWE3. PTN insures the Operation Administration Maintenance (OAM) with synchronization and the full end-to-end circuit protection.

MPLS-TP The Multiprotocol Label Switching - Transport Profile is a variant of the IP-MPLS protocol issue from Internet Engineering Task Force (IETF) together with International Telecommunication Union Telecommunication Standardization (ITU-T). The MPLS applies a Label Switching Path (LSP) on packet from multiple protocols to accelerate the speed of their distribution in Mesh infrastructure or over VPN without packet analysis.

The MPLS-TP is a connection-oriented packed switched profile and the administrator will implement them like circuits of SDH infrastructure. Therefore, MPLS-TP features the OAM functions for the Alarm Monitoring and Alarm Signaling, Traffic Diagnosis and Circuit Performance Monitoring at every layer (Section, LSP, PW). In addition, this layer 2.5 protocol optimizes the transport over PTN infrastructure with enhanced carrier-grade protection switching, OAM and clock synchronization.

TDM, ATM, Frame Relay are carried in point-to-point PWE3 and switched Ethernet is connected in PWE3 for point-to-point or VPLS to support Mesh multipoint.

LER/LSR The Label Edge Router (LER) is referring to the two Edge Routers of a circuit while the Label Switch Router is referring to the intermediate nodes performing Label Switching along the LSP.

LSP The Label Switching Path. The Label pretended to the packet of multiple protocols and to give the information of the Switching Path. Then Multi-Protocol-Routers in MPLS infrastructure will switch the packet very rapidly in the infrastructure.

VPLS The Virtual Private LAN Services over MPLS-TP allows you a Mesh of sites any-point-to-any-point with Layer 2 tunnels for services such Ethernet connectivity and multicast video.

Can we expect from PTN MPLS-TP the same service as SDH?

Synchronization

PTN technology is based on GE/10GE fibers with Synchronous Ethernet (SyncE), and **it provides the same frequency stability as a SDH/SONET** transport network to synchronize all TDM Multiservice interfaces.

Like SDH/SONET ring supports SSM (Synchronization Status Message), the PTN uses ESMC (Ethernet Synchronization Message Channel) messaging to control the better clock selection from all sides.

In addition, each PTN node supports a Precision Timing Protocol (PTP) 1588v2 clock with a precision in transparent mode better than 0.2ns per crossed node. This feature is used to give the phase synchronization for the Ethernet BTS or Node B and for some PLC in high tech applications.

With PTP 1588v2, the PTN technology beats the SDH/SoNET out, in terms of phase synchronization.

Transit time and latency for TDM application

For TDM (SDH/PDH) service, the latency mainly comes from the two LERs performing circuit emulation functions, while the LSRs will contribute minor delay into the circuit latency. The actual latency will vary from settings to settings, such as the clock recovery mode ACR/DCR, and the frames per packet, etc. A typical setting of using DCR clock mode with 1 frame per packet will result in 0.8ms per LER and 10ns per LSR. For an E1 SAToP PW passing through 12 nodes, the total latency will be 1.6ms (0.8ms x2 +10ns x10) approximately.

As oppose to the latency introduced by SDH network, the similar network configuration will result in 0.5ms latency, which is better than PW transportation. Nevertheless, 1.6ms latency caused by PTN transport is acceptable for most of the delay-sensitive application. The result is yet satisfying while using PTN network.

Bandwidth optimization in STM64 or in 10GE

There is no direct answer without designation of the type of traffic the nodes are going to carry.

If we consider the used bandwidth(BW) to transport an E1 in SDH VC12 with overhead is 2.3Mbps and in PTN PWE3 is 3.5~4.0Mbps. In the case of E3 (34Mbps) service transport, the BW used by SDH TUG3 vs E3 SAToP PW are 50Mbps vs. 37Mbps. The utilization rate will be better for lower bit rate TDM data transport over SDH network, while the higher bit rate TDM data will consume less bandwidth when transported over PTN.

In case we are carrying a Gigabit Ethernet of 250Mbps 1520 packet size, the SDH uses VC4-2 or 310Mbps of BW. Same Gigabit Ethernet 250Mbps with 1520 packet size link will use 255Mbps over MPLS-TP VPLS. The MPLS-TP uses less BW to transport Ethernet traffic.

Then in case at least 40% the traffic of the pipe is Ethernet, PTN should support much more effective bandwidth.

Deployment of TDM circuits and static commissioning

IP-MPLS is very performant, dynamic and sophisticate for wide network but requires important knowledge and a costly management.

MPLS-TP is a simplified version with static LSPs and all elements are predictable. MPLS-TP is allowed to create static provisioning End to End of LSPs like how we create the TDM circuits in SDH.

The Loop Telecom iNMS gives the operator the capability to create a circuit from slot3-ifc1 in TDM access multiplexer A to the slot2-ifc2 in TDM access multiplexer Z, each is connected by E1 to SDH A and SDH Z. The iNMS will propose the path over TDM and SDH network and will run the automatic commissioning of each node and create nx64kbps service.

With O9400R-PTN/O9500R-PTN solution the iNMS will propose to create from the same even E1 TDM circuits encapsulated in SDH to SDH VC12 and after in PTN MPLS-TP to PTN MPLS-TP links with PWE3 LSP. The management will setup in the same O9400R-PTN chassis some E1s over SDH VC12 and some E1s over

MPLS-TP PW3 for different destination.

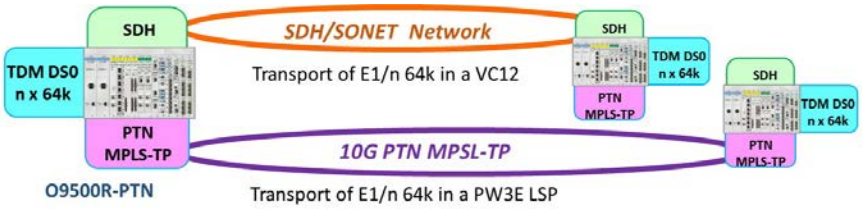

Figure 1-1 E1 TDM transport over SDH/SONET and over PTN MPLS-TP

The deployment of **MPLS-TP is connection-oriented packed switched profile** for TDM and Ethernet and it looks **similar to SDH circuit concept**.

Ethernet transport in SDH, MPSL-TP and Carrier Ethernet

The TDM access gives you the possibility to carry nx64Kbps Ethernet over E1 (EoPDH) as point-to-point.

The SDH gives you the possibility to carry Ethernet or Gigabit Ethernet over SDH/SONET (EoS) but with fixed BW of nxVC12, nxVC3 or nxVC4. E-Line point to point protection is provided by SDH SNCP or MSP. But in the case of E-LAN multipoint, the traffic from SDH East WAN must be converted from SDH to Layer 2 switch and then reconverted to SDH West WAN, and the protection is operated by RSTP. PTN MPLS-TP network can transport in a PWE3 E-Line EoPDH or EoS circuit to be compatible at both ends.

The Ethernet FE/GE/10GE will be transported with more efficiency in MPLS-TP. E-Line point to point can be transported in a PW with LSP, E-LAN any-point to any-point or E-Tree point to multipoint can be transported with a VLPS bridging or H-VLPS bridging. In addition, instead of SDH cards with a limited number of WAN particularly for E-LAN, the PTN node can support up to 2000 VPLS instances. The VPLS crossing PTN node is switched without interruption.

Remark: The Loop Telecom O9400R-PTN/O9500R-PTN nodes support simultaneously the switching from local GE/10GE LAN and WAN interfaces and the transport over GE/10GE WAN interface with MPLS-TP VLSP or Carrier Ethernet. But each WAN interface supports MPSL-TP or CE, not both at the same time.

Protection

The SDH/SONET technology supports MSP 1+1 bus protection and SNCP ring or Mesh protection. Each circuit can be protected independently in the fiber topology. The recovery of service is guaranteed to be within 50ms.

The PTN solution also provides the **MPLS LSP protection 1+1 or 1:1 over bus or multiring infrastructure with a LSP End-to-end recovery of 50ms.** The solution also supports dual homing PW between two chassis.

The power supply CPU, cross-connect, aggregate interfaces can be double for both TDM/SDH and PTN solutions to guaranty the same level of redundancy as SDH.

QoS

The SDH provides the absolute QoS per timeslot by default. The bandwidth of the declared hierarchy with all VC4-x is permanently reserved even they are not used.

While the PTN network level QoS can be enforced by using TC(MPLS)/CoS(CE) Class Mapping into 8 different priority Queues. With Strictly Priority of queue scheduling, the packet with higher priority will be assured 100% earlier than those packets in the lower queue. **Then we can manage the transport of sensible TDM PWE3 circuits with full guarantee of bandwidth and timing like is provided by SDH.**

In addition to the network level QoS, the PTN can further support Tunnel and PW Traffic Engineering CIR/PIR and CBS/PBS Policing/Shaping to achieve the Hierarchical QoS. We can said that PTN technology will provide much more flexibility and variety of QoS than SDH network.

To maximize the utilization of the GE/10GE PTN pipes, the MPLS-TP can support both protected and unprotected LSP. During the installation, we will design the different QoS policies per type of circuits to deploy easily the multiprotocol infrastructure...

OAM

One of the main advantages of SDH is to support a permanent control of the quality of transport from end to end together with the protection activation. Following the similar methodology, PTN OAM borrowing the SDH mechanisms of hierarchical alarms, and performances, diagnoses and protection switching, has come up with a toolset defined in IEEE 8113.1/8113.2 for the same purposes in the case of MPLS-TP. For Carrier Ethernet OAM, the Ethernet Service OAM (IEEE 802.1ag/Y.1731) and Ethernet Link OAM (IEEE 802.3ah) are defined for equivalent purposes.

Up to this point, the PTN OAM is as good as SDH.

SDH and PTN MPLS-TP: competition, cohabitation or migration!

SDH and PTN MPLS-TP are transport solutions of the traffic and must be chosen for the best performance required by the applications and regards to CAPEX and OPEX.

Because the guaranties of services are similar, the interest to use only one or both transport technologies together must depend on the volume and the criticality of the traffic to carry, but also the simplicity to set the customers' applications inside the infrastructures.

We are going to study four cases of choice:

A. In case the number of TDM interfaces still the most important and the Ethernet links are low rate designated for the Automation, the SCADA with some LAN access.

It can be easier to deploy TDM and SDH hybrid devices and to carry the small bandwidth Ethernet links from Ethernet RTU as EoPDH n x 64Kbps links and the large Ethernet, E-LAN from node to node, as EoS over existing SDH network, like O9400R SDH/SONET only or O9500R SDH/SONET with an integrated DS0 Multiservice DACS.

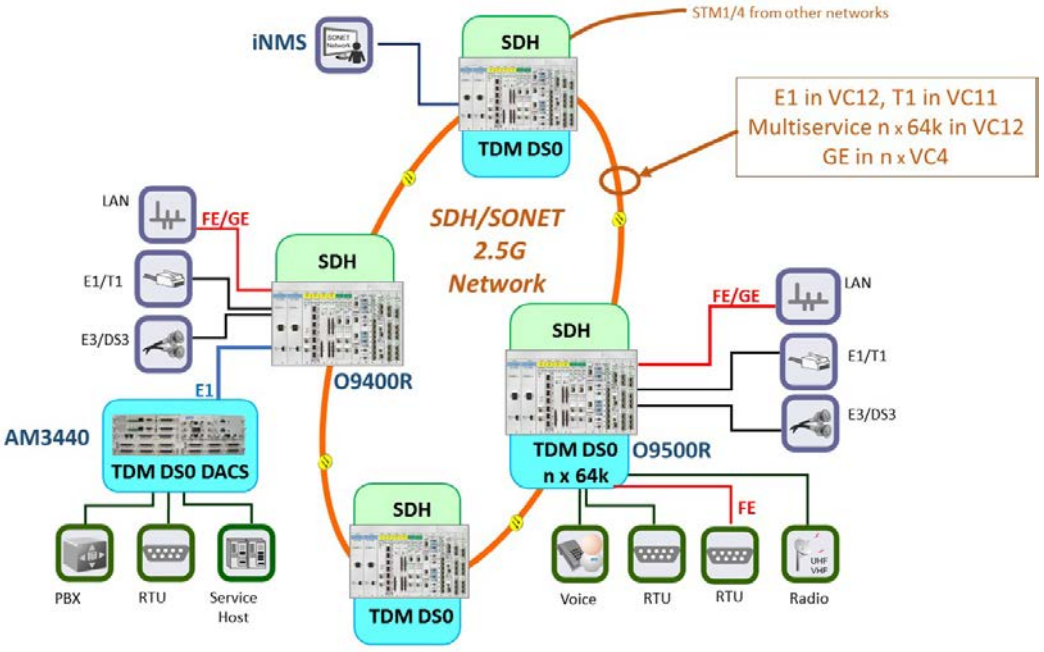

Figure 1-2 Standard SDH/SONET infrastructure with EoS

B. In case the customer wants to keep a stable Multiservice TDM/SDH infrastructure and add large Gigabit Ethernet traffic

The O9400R-PTN/O9500R-PTN equipment can support together up to 2 aggregate SDH STM16 SNCP rings and 3 PTN 10GE rings. Each PTN ring can support MPLS-TP network or Carrier Ethernet in the same chassis.

The customer can maintain his sensible multiservice with SCADA, automation, legacy applications in the conventional SDH/SONET and he will add a large volume of Ethernet in fully independent transport.
Both networks can use the same nodes but also different nodes if the sites do not request all applications. Step by step the customer can apply some Multiservice links over PWE3 LSP to provide such service on pure Ethernet nodes.

To save CAPEX and OPEX, this gives the advantage to support in the same chassis, with the same management, a full Multiservice TDM DACS with a powerful SDH/SONET 4 STM16 multiplexer for transport and a powerful redundant 100GB switch with up to 16 FE/GE and 6 GE/10GE LAN or WAN ports which support the PTN MPLS-TP or Carrier Ethernet Networks.

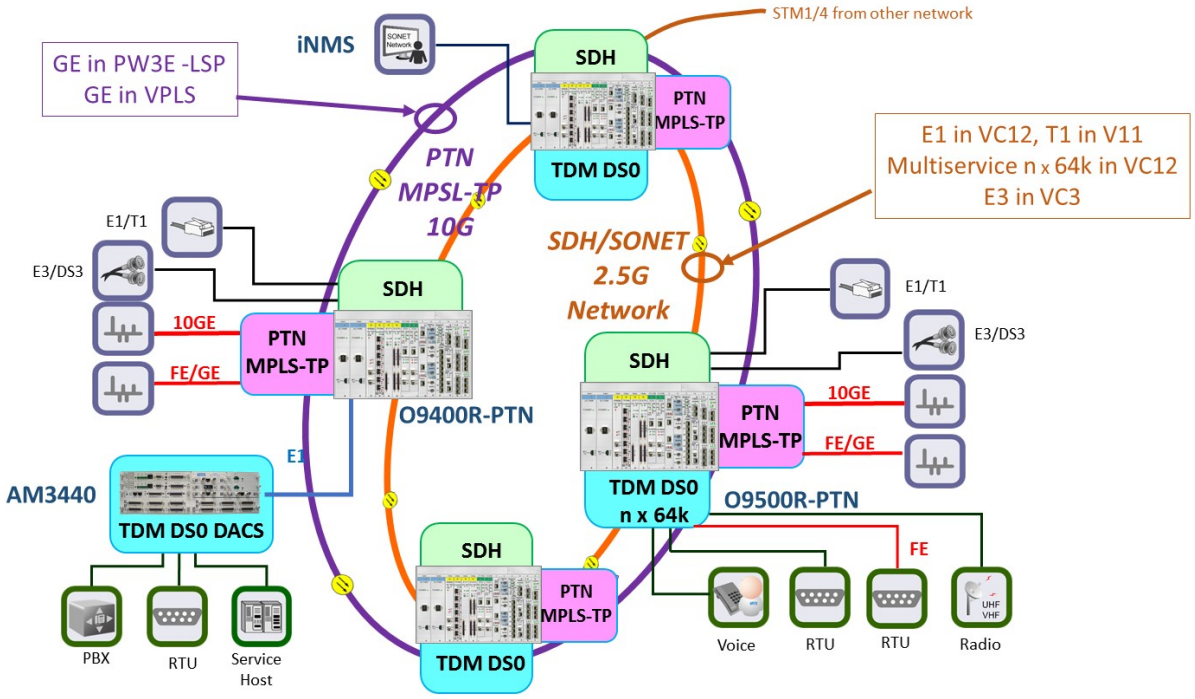

Figure 1-3 Standard SDH/SONET for Multiservice transport and Ethernet SCADA and PTN MPLS-TP for Ethernet transport infrastructure

To save fiber and use the same fiber for SDH and 10GE PTN, Loop Telecom proposes also simple CWDM filter and 2.5/10GE colored SFP or more sophisticated OTN CWDM/DWDM solutions with encryption and amplification particularly for long distance.

The Ethernet over 10G interfaces can be transported with MPLS-TP or in Carrier Ethernet. But only one protocol is available per link.

C. In case the TDM/SDH infrastructure is still in place but some inter-sites are built with GE/10GE

New links are now deployed with 10GE. In this case, it could be interesting to stop the lease of STM/OC fiber and to share these new 10GE.

With the O9400R-PTN/O9500R-PTN these 10GE support PTN with MPLS-TP. Then new Ethernet/ Gigabit-Ethernet traffic can be carried over VPLS and the SDH to SDH traffic will be carried over a PWE3 (VC4-x) LSP.

This maintains the TDM/SDH network without modification and saves the lease of SDH links by sharing the 10GE new links.

The iNMS will set up all devices along the TDM Multiservice circuits from Edge to Edge. These circuits cross TDM DACS, SDH nodes, SDH Networks over VC12, SDH/PTN switches, MPLS-TP network over PWE3 (VC4) and SDH, DACS to the TDM interface.

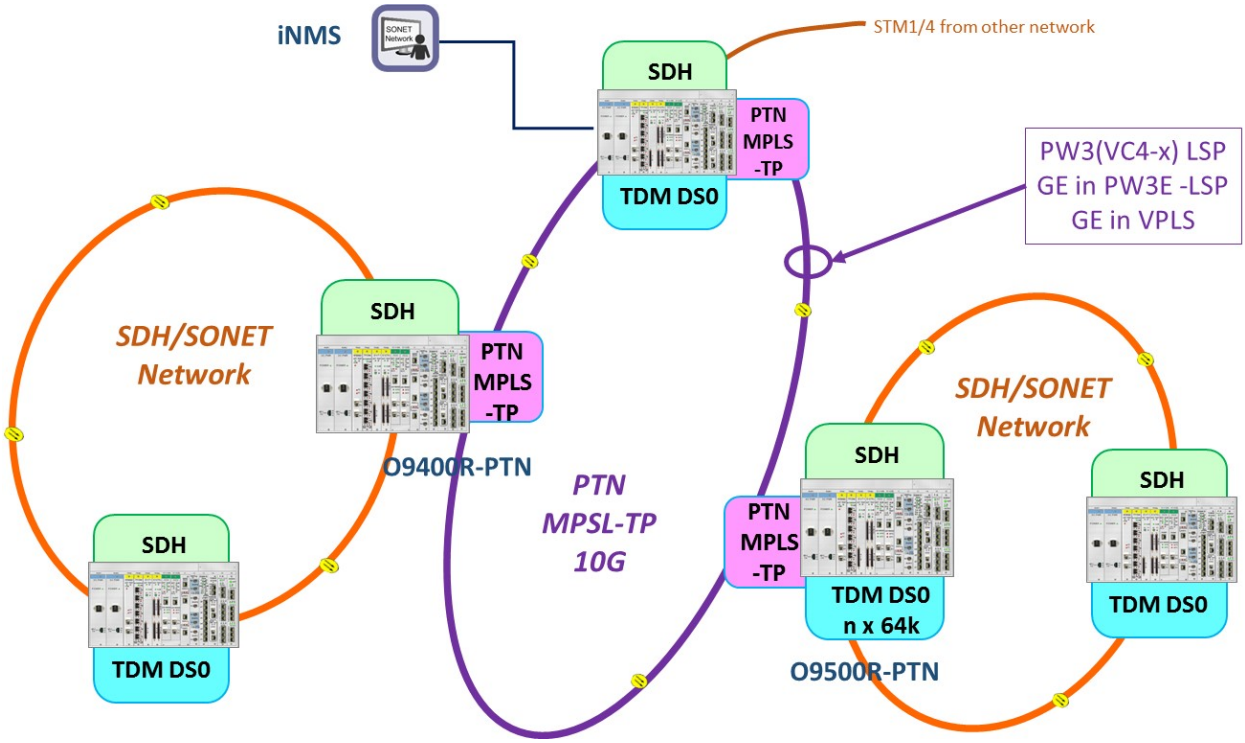

Figure 1-4 Standard SDH/SONET for Multiservice transport and Ethernet SCADA crossing PTN MPLS-TP infrastructure

D. In case the IP/Ethernet traffic becomes the principal volume of the traffic

Even step by step the Multiservice applications will become native IP or Ethernet, many customers must maintain the existing TDM Multiservice from site to site and to NTUs.

If the transport of TDM multiservice is operated by SDH/SONET, the PTN MPLS-TP will take in charge the transport of all circuits. For more efficiency, the E1/T1/FE1/FT1 traffic should be transferred from VC12/VC11 encapsulation to PseudoWires PWE3 LSP and the SDH/SONET services will be deactivated.

The SDH O9400R-PTN/O9500R-PTN provides a large number of E1/T1/E3/DS3 interfaces, with clock independent and will be used as access and conversion from TDM to PTN, or insertion of a STM1/4 from external world in PTN.

In case a SDH/SONET link should be transported edge to edge of PTN infrastructure, like a STM1 ATM, the system will encapsulate the VC4-x/VC4-xc inside a PWE3 LSP with CEP emulation.

The migration can be operated circuit per circuit and during this period of migration the PTN LSP can be protected by SDH/SONET VCxx circuits. At the end of the migration the SDH/SONET services will stopped.

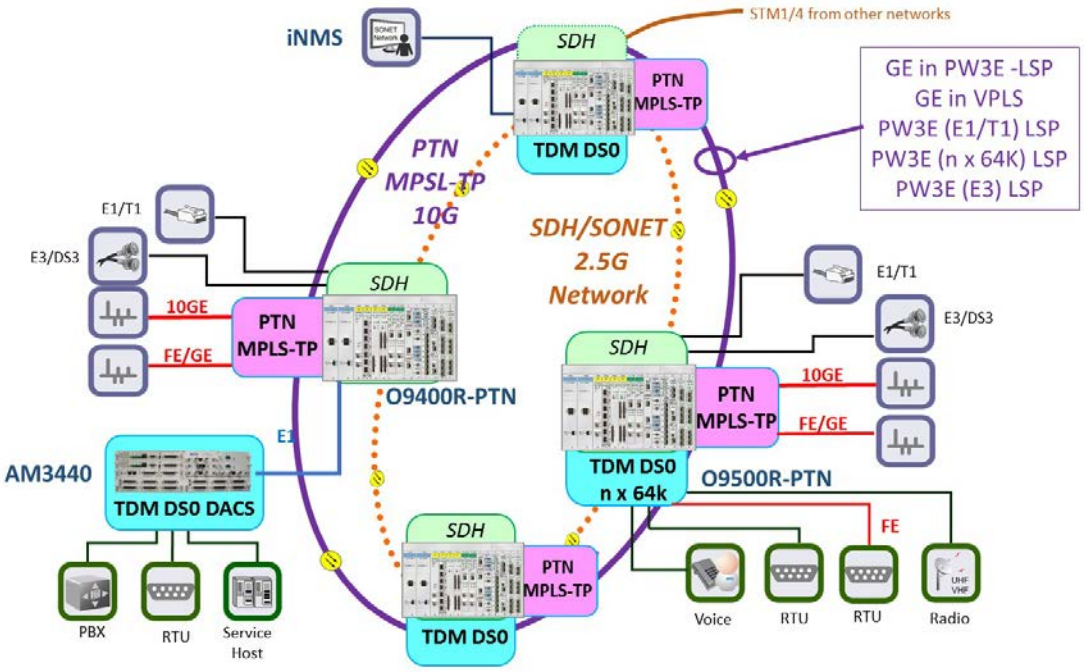

Figure 1-5 PTN MPLS-TP infrastructure to transport Ethernet, Multiservice TDM and eventually SDH links

Remark for Mobile Backhaul Networks

Some major mobile operators are still using E1s for BTS/Node-B connections. They like to maintain this structure to avoid the addition of IP address, gateways and securities only for the transport infrastructure, or backhaul from BTS/Node-B toward BSC or RNC.

They deploy and manage BTS/Node-B as PWE3 over PTN MPLS-TP networks like physical E1 connections.

Summary

For the non-telco applications, the choice to increase SDH/SONET systems to support STM16/OC48 or STM64/OC192 because of growing IP/Ethernet traffic request is certainly not a good solution today.

The Ethernet over SDH/SONET (EoS) transport is not efficient in terms of bandwidth and poor switching possibilities. The migration to PTN MPLS-TP transport with TDM in PWE3 together with large Ethernet volume looks more realistic.

As the IP/Ethernet world transport is going to use IP-MPLS Networks, all VPLS or PWE3 starting from MPLS-TP edges can access inside Core IP-MPLS Network. Then from MPLS-TP edge, users can access to MPLS Cloud.

Except few cases, with the growth of IP/Ethernet volume the migration of the transport TDM/SDH to TDM/PTN with MPLS-TP or hybrid looks generally more profitable.

Loop Telecom will propose you this Universal transport or the migration from Synchronous to Packets with the O9400R-PTN/O9500R-PTN, a powerful universal management iNMS and if necessary OTN solutions.