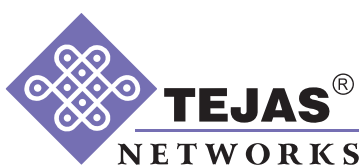# OTN in Access Networks

TEJAS® NETWORKS

Cost-effective option to scale transport networks

Optical Transport Network (OTN) is a telecom technology that has evolved in recent times for use in high-capacity DWDM networks. This paper highlights the benefits of utilizing OTN for Access networks by reducing the overall costs and saving expensive router ports to reduce overall capex spend.

White Paper

Introduction

As the amount of traffic increases in today's networks, there is a need to handle traffic at larger granularities. Besides, as the ratio of TDM to data is constantly shifting in favor of data, there is a need to handle data traffic more efficiently in transport networks. As the transport networks grow larger, they have to be partitioned into several regions or subnets. Since many operators synergize their networks to provide end-to-end services, an easy management of operator-to-operator handoffs is needed. To solve these problems ITU-T laid down the specifications of the Optical Transport Network (OTN). ITU-T provides the general requirements in the G.872 standard and the interface definitions in the G.709 standard.

OTN transport has been in use for a decade, beginning with its use in Submarine Line Terminal Equipment (SLTE) applications in the 1990s. G.709 OTN was originally defined as a point-to-point protocol, designed to provide a protocol-independent wrapper of client data. The objective was to use a single homogenous protocol to wrap/containerize various clients, providing 100% transparent transport, something SONET/SDH was incapable of for Gigabit-speed services such as Ethernet, Fibre Channel, and wavelength services.
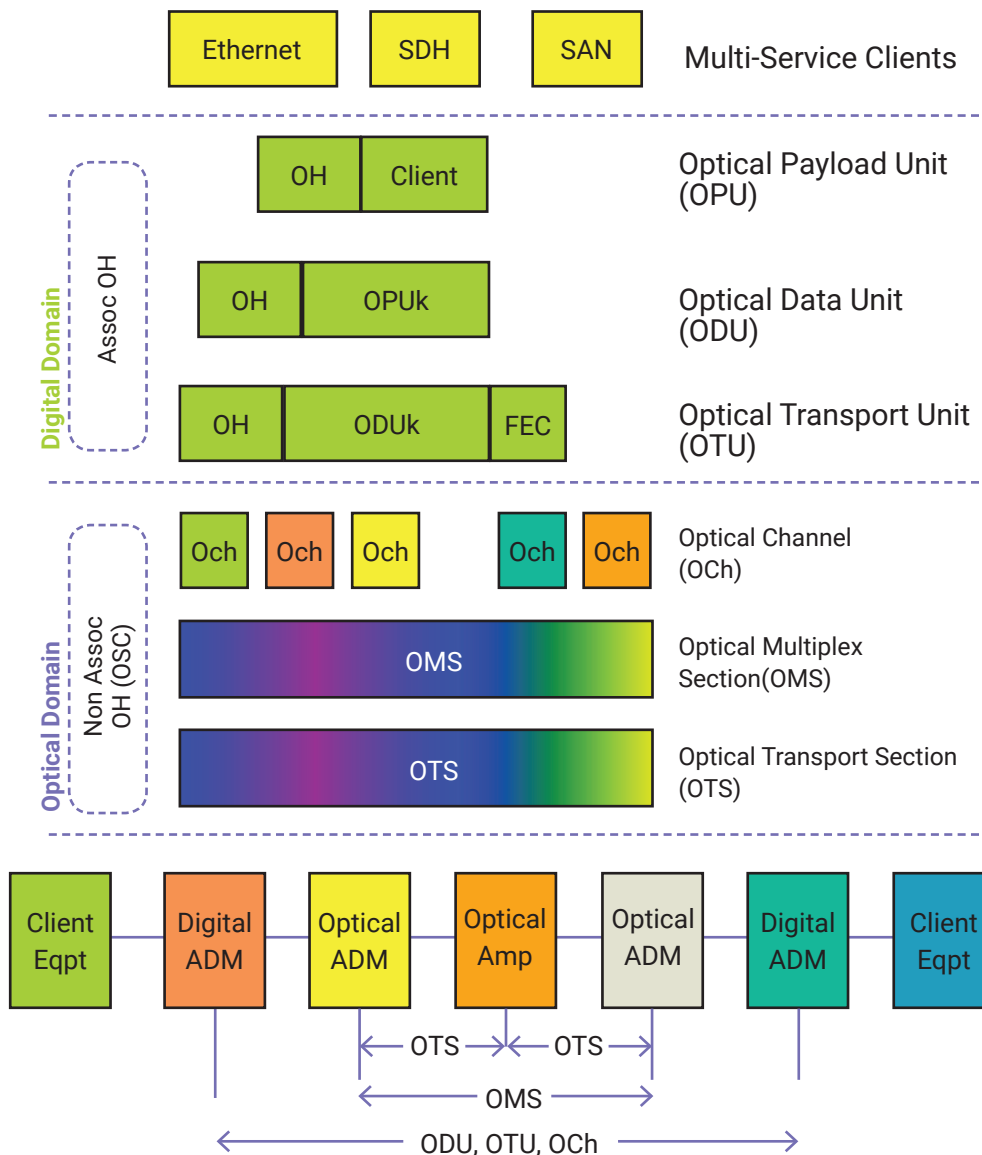

Figure 1 – OTN Architecture

In today's next generation transport networks the optical layer, typically referred to as "Layer 0" or the "DWDM layer", is the most cost effective layer for maximizing fiber network utilization and managing point to point traffic that is 10Gbs and higher. If the traffic pattern is highly meshed, with a large number of wavelengths on each span between nodes and fiber connectivity creates a large number of intermediate nodes for the majority of the point to point traffic, then the addition of Remotely Configurable Optical Add Drop Muxes (ROADMs), also referred to as a Wavelength Selectable Switches (WSSs) will decrease cost. However, if the traffic pattern is primarily hubbed, with less than 20 wavelengths and the vast majority of services being transported are less than 10 Gbs then Optical Add Drop Muxes (OADMS) have the advantage of lower initial cost, simpler maintenance while retaining the ability to support point to point services.

Layer 1, SDH and OTN, switching is the most cost effective layer for point to point traffic between 2Mbs and 10Gbs, while providing robust traffic protection mechanisms and simple provisioning methodologies. SDH grooming provides cost savings for point to point traffic below 1Gbs while OTN provides cost savings for traffic between 1Gbs and 10Gbs. In addition, OTN provides Forward Error Correct (FEC) on DWDM wavelengths to lower the cost of "Layer 0" optical amplifiers by reducing errors on a fiber span. The latest generation of Packet Optical Transport combines SDH and OTN switching into a single fabric allowing for the lowest cost management of traffic.

Ethernet Packet switching, or Layer 2 switching, provides the greatest benefit to traffic that is multi-point and highly meshed throughout the network. Switching traffic at this layer creates a uniform infrastructure for traffic management at the same time as it increases the costs of transporting the traffic. Carrier Ethernet switching capabilities go beyond traditional enterprise Ethernet switches in providing reliability, service management and fault isolation, to make Ethernet as reliable as SDH and OTN.   Creating a network with an optimal cost to benefit ratio is made easy by all three layers and switch traffic in the most cost optimal manner.

OTN in Core Transport Networks

Traditional Use Cases

Initial applications of OTN have been restricted to Core Networks that utilize high-capacity DWDM technology. The three main reasons are:

Tandem Connection Monitoring: OTN supports six levels of Tandem Connection Monitoring. This is a significant improvement over the one level provided by SDH. With six levels of TCM, the network can be partitioned into six level of hierarchy from a management perspective. Some of these levels might be defined by a single operator to manage his large network, or for managing multi-vendor subnets within his own networks or for hand-offs between multiple operators.

Efficient Sub-Lambda Grooming: DWDM layer is capable of handling traffic at a wavelength layer providing either a 10Gbps or a 40Gbps granularity in the DWDM network depending on the interface used. Since DWDM by itself does not offer any way to consolidate partially filled wavelengths, this leads to a lot of bandwidth wastage. OTN solves this problem by providing sub lambda grooming through an OTN cross-connect.

Reduced Build and Operational Costs: On a cost per Gbps of switching capacity, routers tend to be much more expensive than OTN fabrics. By substituting OTN for a significant part of the switching capacity (the transit traffic), the overall cost is reduced significantly. Also, OTN fabrics consume less power compared to routing fabrics. They also consume less power than SDH fabrics since they groom traffic at 1Gbps granularity instead of 2Mbps.

However, in recent years OTN technology has been recognized as a good fit for Access networks also.

Key Drivers for OTN in Access

High-Bandwidth Transport

Delivering high bandwidth, point-to-point services greater than 1G is becoming increasingly important in today's access networks. These services could be packet-based (e.g., Gigabit Ethernet) or TDM-based (e.g., STM-16). Typically these services do not require switching or grooming at intermediate nodes but they do require reliability and effective OAM. OTN is optimized for such requirements since besides being a transport protocol it can flexibly cater to the transition of traffic from TDM to Packet and scale from low bandwidth to high bandwidth.

Transport-style reliability

OTN's reliability functions are modeled on the lines of SONET/SDH technology with the same level of versatility. OTN incorporates the following reliability features

  i. **Comprehensive OAMP:** Messages related to Loss of Signal/Frame (LOS/F), alignment errors (TIM), frame errors (BIP-8, BEI), alarm indications (AIS, BDI) enables fault diagnostics at the OTN layer
  ii. **Range of protection schemes:** OCh 1+1, OCh-SPRing, ODU-1+1 linear, ODU-SNC/I, ODUSNC/N, ODU-SNC/S, and ODU-SPRing are analogous to popular linear and ring protection protocols in SDH/SONET
  iii. **Mesh-based automatic restoration with a GMPLS control-plane:** Offers additional flexibility by reducing the need for pre-allocated protection bandwidth on a backup path and for manual intervention by a network operator

FEC for extended reach in the Access

OTN supports FEC (Forward Error Correction) based on Reed-Solomon (255/239) with 16-byte parity. While SDH too has defined an in-band FEC, it is fairly rudimentary. OTN FEC, on the other hand, can correct eight bytes of error per sub-row or detect up to 16 byte errors (without any correction) resulting in a 6.2 dB improvement in SNR. The availability of an enhanced FEC function can result in tangible cost savings in the access by reducing the need for external amplifier elements (often unmanaged) or more expensive long-reach interfaces.
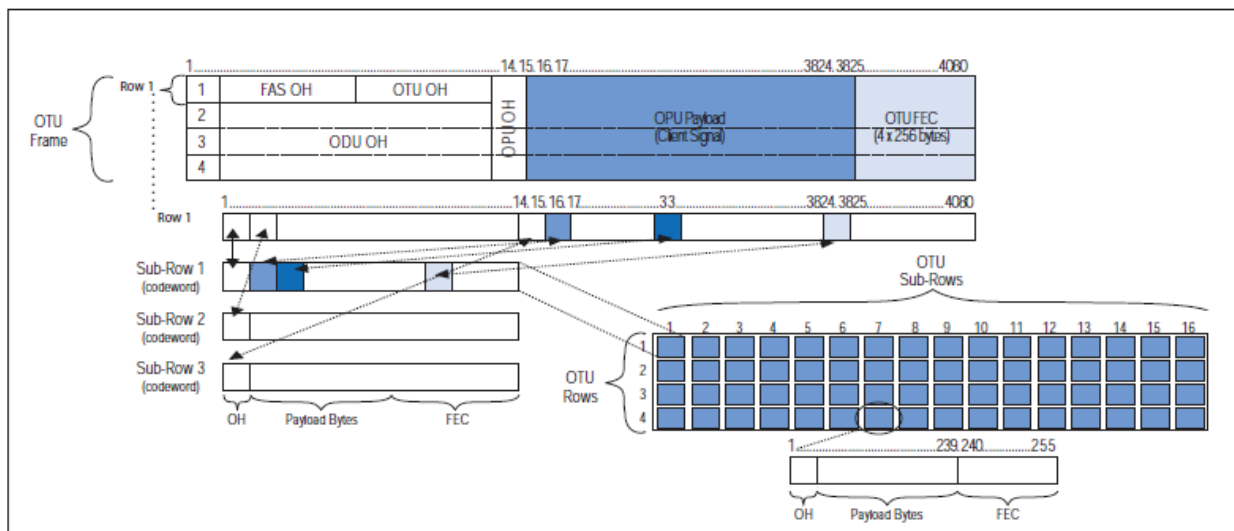

Figure 2 – FEC Calculations in OTN

Transparent Service Transport

Unlike SDH, OTN can achieve truly transparent service delivery because it uses asynchronous mapping. For example, if OTN is being used to transport an SDH client, it will neither modify any of the SDH overhead bits nor will the timing information be touched. This is especially important in the context of defence networks and other security-sensitive transport requirements.

Packet Switching Bypass

There are many emerging time-critical applications (e.g., video on demand, video conferencing) that call for a simple and effective transport of client traffic with the lowest possible latency. In such cases, even if the client happens to be a packet interface, it is particularly advantageous to use OTN as the transport protocol in the access network. This is because OTN does not have a store-and-forward architecture like in the case of packet switching thus avoiding unnecessary delays, jitter and service impairments. This approach will also free up capacity in packet switching fabrics (e.g., Ethernet switch) for applications that actually require intermediate processing thus lowering the overall cost of the access network.

ODUflex for Bandwidth Reclamation

ODUFlex is a recent feature in OTN that is particularly suitable to accommodate a range of new and custom client signal rates that are emerging in the Access. Examples are EPON, GPON, CPRI that are fast gaining popularity as the Access is increasingly fiberized to deliver gigabits of bandwidth to user locations, whether offices or residences. With ODUflex, the container can be the exact size of its client, leaving the remaining space for other client signals. ODUFlex can carry both Constant Bit Rate (CBR) and Variable Bit Rate (VBR) packet-based clients. CBR clients are mapped using Bit-Synchronous Mapping Procedure (BMP) and packet-based client signals are accommodated by using Frame-mapped Generic Framing Procedure (GFP-F). ODUFlex is then mapped into a number of time slots in a High-Order ODU (HO-ODU) by using Generic Mapping Procedure (GMP). The clear advantage of ODUflex is that unused bandwidth on existing fiber can be reclaimed and the operator can avoid burning an additional fiber pair to meet new traffic requirements. This is critical in Access networks with fiber exhaust issues.

CPRI, SDI, SerDes — Ckt ODUflex

VLAN/MPLS-TP LSP — Pkt ODUflex

Figure 3 – Achieving Bandwidth Flexibility through ODUFlex

Frame Encryption for Secure Transport

In OTN, bulk encryption can be performed with fixed-size frames that hold several advantages when compared to variable-sized, packet-level encryption. Frame encryption can be uniformly applied to clients of all types and there is no throughput penalty since there is no per-packet overhead. OTN encryption is not susceptible to traffic analysis and the larger size of frames makes cryptanalysis significantly harder. There are no scalability constraints and OTN encryption systems can be designed for all rates (10G, 40G, 100G). Also, only one encryption system has to be designed per signal rate.

POTP: The Ideal Platform for OTN

Packet Optical Transport Solutions (POTS) evolve TDM centric SDH networks into a packet centric optical in the most efficient and cost effective manner possible. The primary component of a POTS network is the Packet Optical Transport Platform (POTP) which combines SDH, Packet, OTN and C/DWDM switching into a single network element delivering services across a common infrastructure. By combining these transport switching capabilities, a POTP can ensure the most cost effective transport of traffic by grooming traffic at the lowest cost layer in the network.

OTN in the Access is best delivered on a POTP platform as opposed to being integrated in IP/MPLS routers for the following reasons:

a. **Interface costs:** The price of an OTN interface is observed to be significantly higher on an IP router. This is because of the additional overhead costs related to expensive buffers, network processor units and memory chips used on routing platforms.

b. **Power and density:** The overall power dissipation footprint for an IP router is also higher due to the complexity and sophistication required to meet the packet processing functions. This has an adverse impact on the density and scalability achievable when compared to best-of-breed metro/micro POTP platforms.

c. **Operational paradigm:** Historically, network operators have preferred to separate routing and transport domains since the nature of skill sets, training needs, provisioning, maintenance, and management processes are very different for the two.

d. **Link integrity:** OTN has evolved new standards for OAM interworking between packet and transport infrastructures. It meets carrier requirements for sub-50ms fast failover and recovery for high-quality IP traffic carried as Ethernet over OTN. Both pro-active signaling (Link degradation) and post-facto signaling (link failure) protocols are supported.
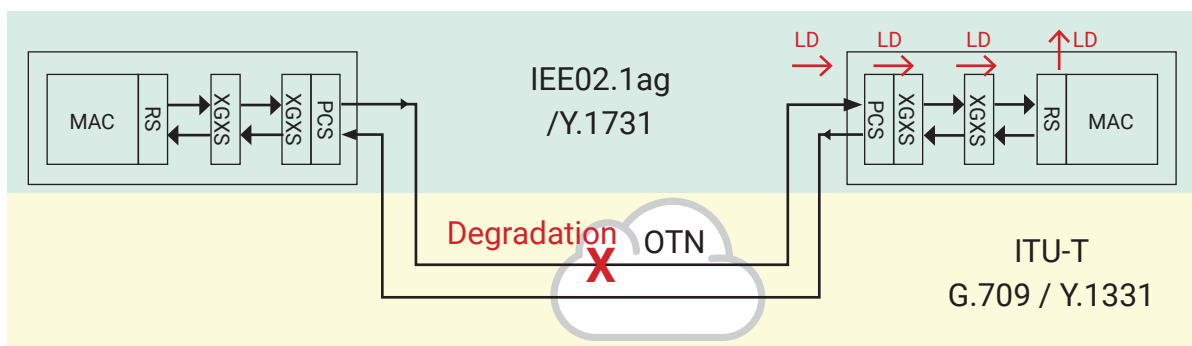

Figure 4 – Link degradation signaling for Ethernet over OTN (source: ITU-T)

Tejas OTN product

Tejas Networks' POTP platform with integrated OTN switching increases bandwidth efficiency through sub lambda grooming that enables deployment of fewer wavelengths leading to significantly lower network costs in large deployments. Converging of multiple technologies such as SDH, DWDM, PTN and OTN in a single shelf, reduces the number of nodes required to be collocated at each site. Thus the overall capital expenditure is lowered. Tejas products are coupled with a multilayered management system that simplifies end-to-end service provisioning and network configuration to reduce the operational expenditure.

Conclusion

OTN represents a significant improvement over existing transport technologies and is emerging as the most efficient and cost-effective option to scale today's networks. Although the initial applications of this technology were limited to core DWDM networks, OTN is now penetrating Access networks as well. OTN complements Carrier Ethernet switching in the Access and is primarily deployed in POTP platforms.

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