WHITE PAPER

Optelian

Vertical OTN

The Evolution of Optical Networks

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Network operators have traditionally used a physical overlay model in their networks, where different platforms are used for different networking layers. Although conceptually simple, the implementation is complex; it involves a mix of equipment from multiple vendors with different form factors, the need to train people on multiple management systems, the potential for functional duplication across layers, a lack of visibility and control across multiple layers, and an overall increase in CAPEX and OPEX. For this reason, there is a trend toward converging network layer functionality onto a common platform.

The trend toward converging network layer functionality onto a common platform primarily involves converging Layer 0 (DWDM), Layer 1 (TDM) and Layer 2 (packet), but may also include Layer 3 and above. The approach to convergence among network operators and system vendors can be quite different. One approach avoids Layer 1 altogether and uses Layer 2 directly over DWDM; another approach makes Layer 1 OTN ODU switching central to its architecture. There is a third approach, which we will call vertical OTN (V-OTN), that provides the modularity and flexibility not possible with other architectures. Each approach to a converged architecture has its place in a network, and the merits of each are discussed in this paper.

Packet over DWDM

With this approach, switches and routers have integrated DWDM optics, interconnected directly over an underlying DWDM infrastructure, all controlled under one management system. This may be referred to as a pure packet transport system (PTS) and is arguably the most forward looking architecture, assuming the services being carried are entirely packet-centric. Packet aggregation and processing and statistical multiplexing can occur anywhere in the transport network, providing the ultimate flexibility for flow virtualization. It has the potential to remove "all of the air" in a network and provide the highest wavelength utilization efficiency possible.

Packet-centric networks, however, cannot deliver real circuits. They can emulate connection-oriented services with pseudowires and technologies like MPLS-TP or PBB-TE, but no matter how many RFC or other standards are thrown at the problem, they will never be able to provide a transport "circuit" in the real sense. All of the efforts to provide class-based flow control with sophisticated traffic engineering are important and necessary to virtualize and emulate circuits in a pure packet network, but the fact remains that packets are statistical by their very nature, so there will always be some level of contention and uncertainty in latency and packet jitter that network flows must accommodate. For higher speed TDM client services and/or circuits with high jitter and latency sensitivity, pseudowires and circuit emulation simply do not cut it.

OTN Switching

With switched OTN, transport circuits are the real deal. Each client service is mapped into an ODU TDM flow, which is then switched as a TDM flow throughout the network, just as with SONET/SDH. In this case, the bandwidth, latency and jitter for the circuit are static and unconditionally guaranteed. There is no need to emulate a circuit or "SONET-like" OAM, because it is intrinsic to a Layer 1 switched network.

OTN switched networks can accommodate any mix of client services and protocols, just as next-generation SONET/SDH can. However, OTN provides more levels of tandem connection monitoring for fault localization, leverages forward error correction, does not require tight synchronization, and provides efficient mapping and grooming functionality for GbE and higher speed clients.

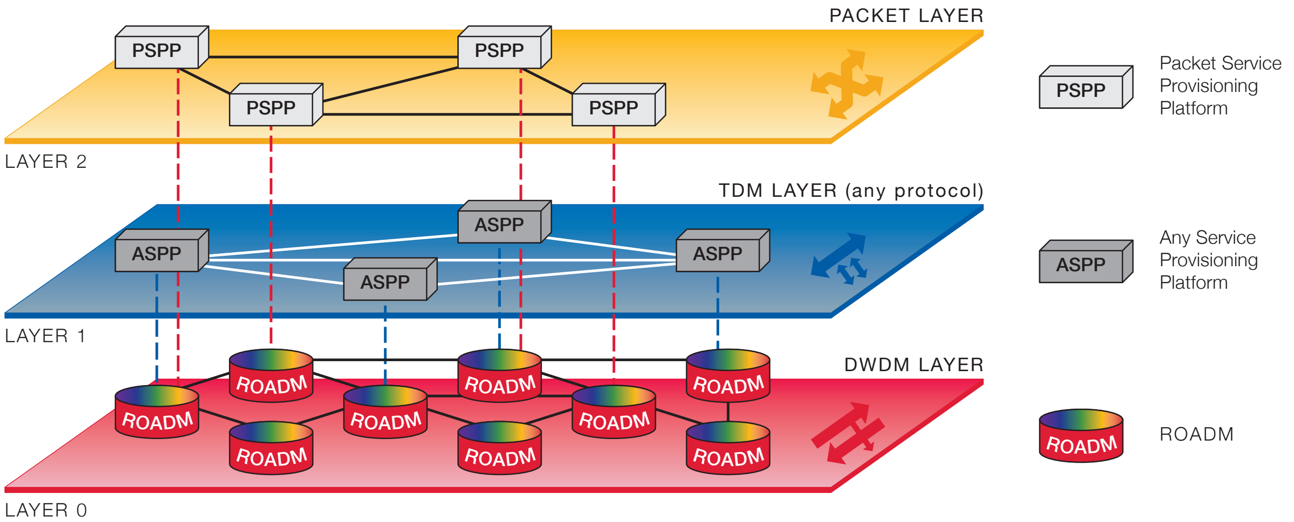
Platforms that implement ODU switching usually offer some level of Layer 2 aggregation and switching capability, and integrated DWDM/ROADM functionality, usually referred to as a packet optical transport platform (P-OTP). Once packets are mapped into an ODU flow, however, it is not possible to further process packets and do additional packet aggregation without first terminating and unwrapping the ODU flow.

Platforms built around OTN switching tend to be big boxes with a centralized switching fabric and data backplane, and just as with SONET/SDH, they are a big commitment to a TDM-centric network.

Vertical OTN

Vertical OTN (V-OTN) is essentially a modularized hybrid of a PTS and P-OTP that does not lock the architecture into either a pure packet or TDM-centric paradigm. It assumes that a network will evolve toward pure packet over time, without compromising the ability to support TDM-centric networking from day one. It uses a conventional vertical overlay model, but on a common hardware and software platform using networking sub-platforms or cards, as shown below.

Unlike a P-OTP, OTN switching is not central to or required with V-OTN. Instead, OTN is used purely as a transport technology for wavelength connections at Layer 0, and to connect trunk ports on Layer 1 and Layer 2 networking equipment; i.e., as a "vertical" technology across all layers. The forward error correction capabilities of OTN are essential for wavelength connections at all of these layers, because it allows such connections to be viable and error-free in the presence of physical impairments, such as dispersion, cascaded filtering, noise and interference.



V-OTN recognizes the need to accommodate true Layer 1 circuits, but without making TDM central to the architecture. True TDM circuits can be accommodated using transponders or muxponders where appropriate, but more importantly with an any-service provisioning platform (ASPP) that provides sub-wavelength aggregation and any-to-any TDM-centric networking. Such ASPPs are essentially an MSPP on a blade, but support a larger set of client protocols (essentially any protocol) and have integrated OTN wrapping on trunk interfaces. Although Layer 1 mesh topologies are possible, ASPPs would typically be interconnected in a protected ring topology over a mesh DWDM infrastructure, providing a simple protection mechanism for TDM circuits compared to mesh-based protection schemes. Any TDM-based technology, including SONET/SDH, ODU multiplexing, or proprietary technology, may be used in an ASPP, as long as it realizes true Layer 1 circuits.

Similar to an ASPP, a packet service provisioning platform (PSPP) can be overlaid in ring or mesh topologies to support pure Ethernet and/or MPLS transport. Again, OTN would be used to interconnect trunk ports on PSPP networking cards or sub-platforms. A PSPP could be a card or a small rack, or even an entire bay. The combination of a PSPP with Layer 0 essentially represents a PTS.

The capabilities of a P-OTP, PTS and V-OTN are summarized in the table below:

Capability	P-OTP	PTS	V-OTN
100G+ wavelengths	🟢	🟢	🟢
Fiber capacity ≥ 8 Tb/s	🟢	🟢	🟢
Modular Network Component Layers	🟡	🟡	🟢
Converged, Multi-Layer Architecture	🟢	🟢	🟢
TDM Circuits	🟢	🔴	🟢
Layer 2 Aggregation	🟡	🟢	🟢
Pay-as-you-grow	🟡	🟡	🟢

Conclusion

V-OTN provides a more modularized, pay-as-you-grow architecture, allowing TDM-centric and packet-centric networking sub-platforms to be targeted at only those nodes that need such functionality. It can also be cost-effectively deployed with pure Layer 0 functionality at some or all nodes, allowing it to efficiently integrate with Layer 1 or Layer 2+ equipment from other vendors in a true conventional overlay for those cases that need it. V-OTN offers the conceptual simplicity of a conventional overlay network, while also achieving the objectives of a converged network by offering common hardware, management and control across multiple layers.

Author Biography

Sheldon Walklin (sheldon.walklin@optelian.com) is Chief Technology Officer at Optelian. He received a BSc with distinction and a PhD in Electrical and Computer Engineering from the University of Alberta in 1992 and 1997, respectively. In the mid '90s he pioneered research at TRLabs on advanced modulation formats for high-speed optical transmission. He has been a Radio System Designer at Nortel, Senior Designer at RIM, Optical System Designer at Innovance, Control System Designer and Manager of Hardware and Software at Metconnex, Systems Architect and Director of Systems Architecture at Optelian, and was appointed as Optelian's CTO in 2010. He is a member of the IEEE Communications Society, Photonics Society and CREATE Program Committee for Next Generation Optical Networks.

About Optelian

Optelian provides Intuitive Packet Optical Networking™ to deliver next generation services. Our solutions are enabled by the modular Optelian FLEX Architecture™ to deliver services from access to core, passive to packet, and 100M to 100G. Intuitive Packet Optical Networking enables Service Driven Networking, allowing operators to rapidly deliver services while optimizing network capacity. We enable intuitive service management through a simplified infrastructure that virtualizes network and technology complexity.

With agile design capabilities and North American manufacturing, Optelian can meet custom requirements to suit any network. Combined with professional services to ensure your network is optimally planned and deployed, along with world-class customer support, Optelian delivers the technology and services that enable intuitive next generation networks. For more information, visit www.optelian.com, and follow us on Twitter @Optelian.

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