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10 Gigabit Ethernet Interconnection with Wide Area Networks

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Introduction

By far, the most widely used networking technology in Wide Area Networks (WANs) is SONET/SDH. With the growth of Ethernet now into Metropolitan Area Networks (MANs) there is a growing need to interconnect Ethernet LANs and MANs to these prevalent SONET networks. With the advent of 10 Gigabit Ethernet, the commonality of line rates between OC-192 SONET and 10GE has opened up the opportunity to simplify the interface. This paper describes how 10GE nodes can easily interconnect with OC192 SONET networks without leaving the Ethernet cost model behind.

Background

As described in the “10 Gigabit Ethernet Technology Overview White Paper”, there are two 10GE PHY types specified in the IEEE P802.3ae draft standard by the 10GE Task Force: the LAN PHY and the WAN PHY.

The LAN PHY encodes the 10.0 Gb/s data stream from the MAC to a 10.3125 Gb/s signal using the 64B/66B Physical Coding Sublayer (PCS). The WAN PHY uses the same PCS operating in rate adaptation mode to ensure the output data stream will match the payload carrying capacity of a SONET OC-192 signal (or equivalently an SDH STM-64). The WAN PHY also incorporates the WAN Interface Sublayer (WIS) to provide a simplified SONET framer function as well as the complement of SONET/SDH compatible MIBs. The output of the WIS is an OC-192 frame compatible signal.

The only difference between the LAN PHY and the WAN PHY is the WIS sublayer. Both share the same PCS and serial Physical Medium Attachment (PMA) and Physical Medium Dependent (PMD) sublayers. In this way, the cost benefit from economies of scale applies to both PHY types.

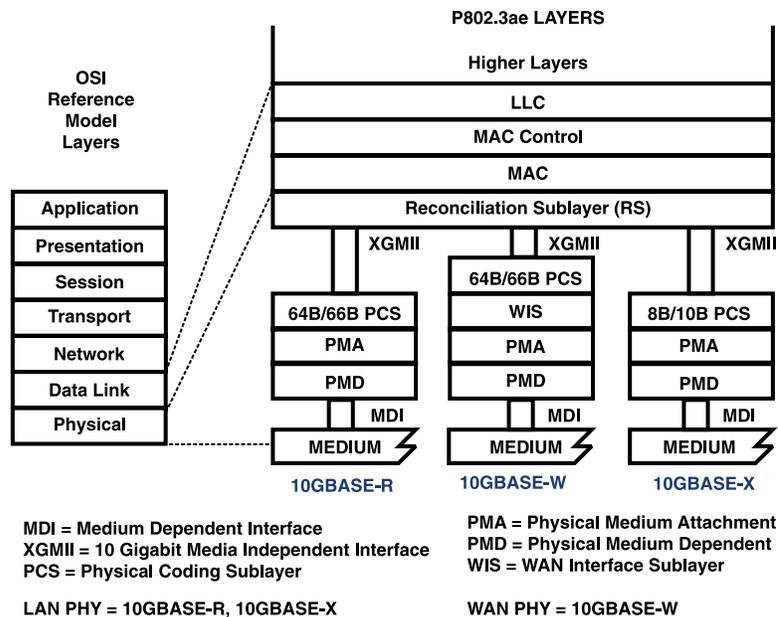


Figure 1: Architectural Components of the LAN PHY and WAN PHY

Motivating Factors for the 10GE WAN PHY

Previous generations of IEEE 802.3 Ethernet standards (i.e. 10 Mb/s, 100 Mb/s, 1 Gb/s) were not near the traditional interface bit rates of transport equipment in the wide area, such as DS-3 (45 Mb/s), OC-3 (155 Mb/s), OC-12 (622 Mb/s), and OC-48 (2.5 Gb/s). Out of necessity, an extra piece of equipment was required in the network to convert Ethernet rates (including protocol conversion) to those accepted by transport equipment.

10GE offered the potential for an Ethernet solution aligned with the 9.953 280 Gb/s rate of the OC-192 backbone. For the first time in the history of Ethernet, no additional speed matching equipment would be required to link with the WAN. A seamless, end-to-end Ethernet network could be built at lower network cost.

The challenge in defining the 10GE WAN PHY was to strike a balance between compatibility with the installed base of OC-192 equipment while still meeting the economic feasibility criteria of the P802.3ae Task Force. To achieve this, the WIS sublayer provides an OC-192 frame format supporting only the SONET overhead features required for fault isolation. This simplification avoids unnecessary functions and cost, such as the section and line datacomm channels, local and express orderwires, etc.

To ensure that the WAN PHY optics would benefit from the high volumes and low cost typical of Ethernet, the serial 1310 nm and 1550 nm optics (or PMDs) were kept the same as the LAN PHY. With the 1310 nm and 1550 nm optics targeted for up to 10 km and 40 km links respectively, they will interoperate with OC-192 optics for 1310 nm and 1550 nm intermediate reach, respectively.

10GE WAN PHY Interconnection with the Wide Area

During the late 1990s, much of the wide area backbone was upgraded to OC-192 line rate. Dense Wavelength Division Multiplexing (DWDM) also emerged during this period. Most DWDM equipment adheres to the ITU-T wavelength grid (per G.692) while using proprietary overhead for wavelength management.

At the edge of the wide area, a new class of equipment was born: the wavelength translator or transponder. This equipment converts the relatively shorter reach (e.g. <40 km) metro signals from loose wavelength tolerance 1310 nm optics to longer reach, tight wavelength tolerance 1550 nm optics on the ITU-T grid. Since the incoming or “on-ramp” signals were SONET format, the chipset from a SONET regenerator could be used. The key difference between a SONET regenerator and a transponder is that the regenerator would have ITU-T grid optics on both sides.

A 10GE WAN PHY signal can be connected directly to a transponder. As the transponders are based on regenerators, section overhead is added by default. The section overhead is used within the SONET backbone for management (e.g. datacomm channel, orderwire). A seamless end-to-end Ethernet connection can now be established without the need for intervening equipment to perform data rate or protocol conversion, thereby reducing network cost.

During the IEEE P802.3ae 10GE standardization process, a general term was needed to refer to the suite of functions inherently provided by a transponder from a 10GE perspective. Although somewhat of a misnomer, the term Ethernet Line Termination Equipment (ELTE) was selected. It is important to distinguish the ELTE as a set of functions inherent to existing equipment rather than as a new standalone device.

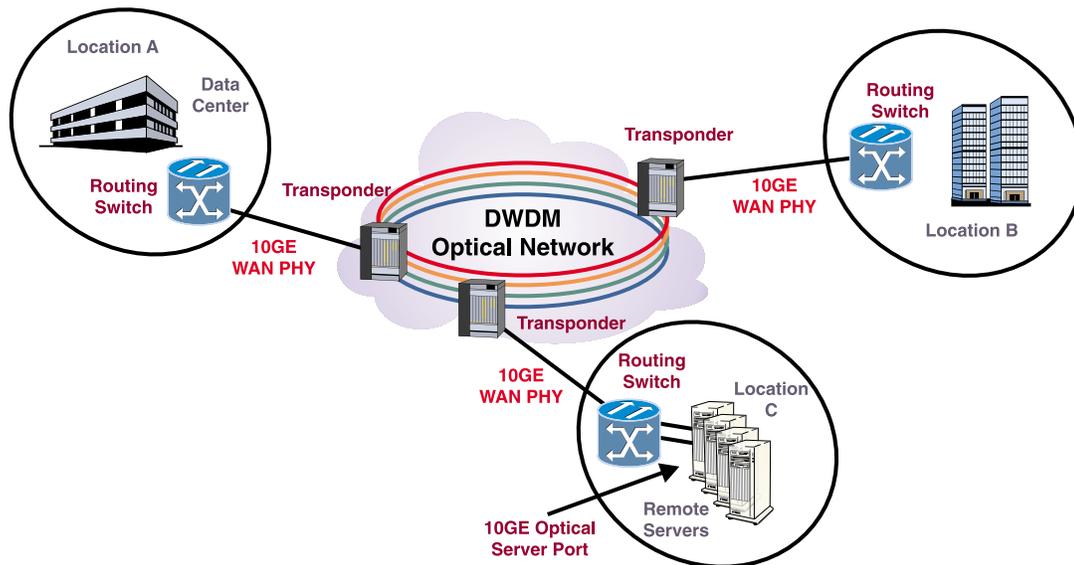


Figure 2: 10GE WAN PHY Interconnect With Transponder/DWDM Network

Evolution of the Metro and Wide Area

With increasing deployment of DWDM equipment in the wide area backbone and also in metropolitan area networks, ANSI and ITU-T initiated standards activity to define a common method for managing multiple wavelength systems – the Optical Transport Network (OTN).

A new generation of transponder equipment that is OTN-compliant is now starting to emerge. Since one of the defined OTN client signals is OC-192 rate, a 10GE WAN PHY signal can be connected directly to an OTN transponder. The OTN transponder “wraps” the client signal with an OTN frame and overhead, hence the often heard term “digital wrapper”. This additional frame and overhead raises the line rate by ~7%, so a wrapped OC-192 runs at 10.709 Gb/s. The 10GE LAN PHY, with a line rate of 10.3125 Gb/s, is not a defined client signal of the OTN.

As traffic growth in the backbone fills up available OC-192 wavelengths, the next generation of line-rate systems will be needed. Effort is already underway in ANSI and ITU-T to define an OC-768 format. For a 10GE WAN PHY (or any SONET signal) to traverse a multiplexed SONET network, the timing handoffs are accommodated by SONET pointer adjustments. The 10GE WAN PHY addresses this future application by specifying that the receiving WAN PHY support a mechanism for pointer processing.

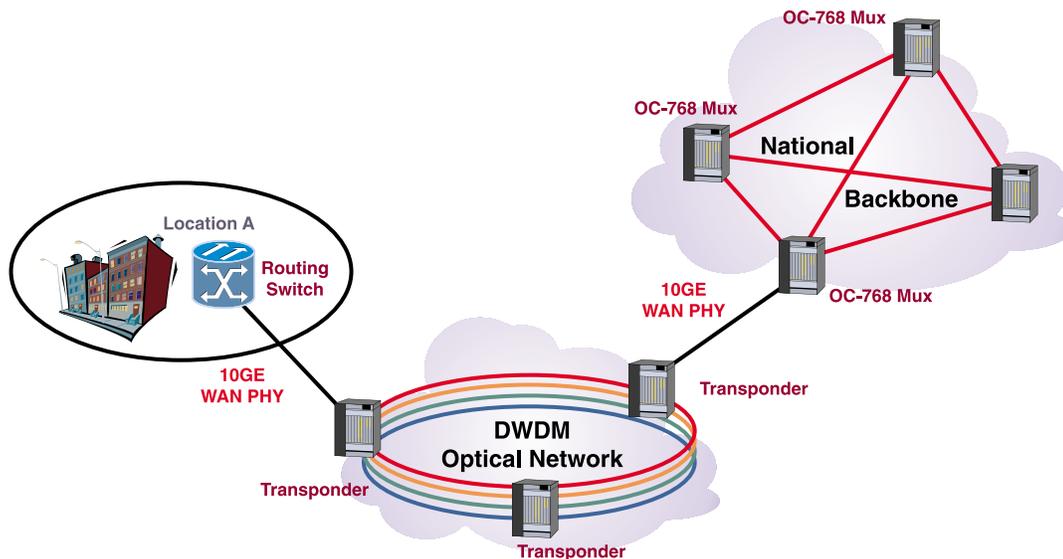


Figure 3: 10GE WAN PHY Interconnect with OC-768 Backbone

Conclusion

With the convergence of Ethernet and SONET at 10 Gb/s, the 10GE WAN PHY defined by the IEEE P802.3ae Task Force will enable seamless, end-to-end Ethernet connectivity via:

- Direct attachment of the 10GE WAN PHY to today's SONET/SDH transponders, providing access to the installed base of DWDM.
- Direct attachment of the 10GE WAN PHY to emerging ITU OTN transponders, providing access to the next era of wide area infrastructure.
- Direct attachment of the 10GE WAN PHY to an OC-192 tributary interface, providing access to future OC-768 systems.

Acronyms

ANSI – American National Standards Institute

DWDM – Dense Wavelength Division Multiplexing

ELTE – Ethernet Line Termination Equipment (a term of convenience)

ITU-T – International Telecommunications Union – Transport Standardization Sector

LAN – Local Area Network

MAC – Media Access Control layer

MAN – Metropolitan Area Network

MIB – Management Information Base

OTN – Optical Transport Network (defined by ITU-T)

PHY – Physical layer comprised of the PCS + PMA + PMD sublayers

PCS – Physical Coding Sublayer

PMA – Physical Medium Attachment sublayer

PMD – Physical Medium Dependent sublayer

SDH – Synchronous Digital Hierarchy (ITU-T term)

SONET – Synchronous Optical Network (ANSI term)

WAN – Wide Area Network

WIS – WAN Interface Sublayer (distinguishes the WAN PHY from the LAN PHY)