Challenges of 2.5G to 10G Migration in Optical Networks

There are a number of challenges involved in moving from 2.5G to 10G networks, including cost of new equipment, technical issues, and the need to operate with existing infrastructure and preserving existing investment.

Michael T. Moore, Cypress Semiconductor Over the years, the exponential growth of the Internet has been fuelled primarily by Internet Protocol (IP) traffic, creating an insatiable demand for bandwidth to carry this traffic. 2.5G optical technology is established in networks today, and equipment and component vendors are focusing their efforts on designing the next generation 10G and 40G systems of the future to satisfy this demand for bandwidth.

This present and future demand for bandwidth poses parallel problems for transport network providers, as they need to both increase the capacity of existing network infrastructure and deploy new networks to service this demand. Their goal is to offer low cost data transport solutions with value added services such as dynamic bandwidth allocation, guaranteed service availability, and Quality of Service (QoS) for premium services.

The reasons behind this growth include the dramatic rise in the number of Internet users. Another driving factor is the shift in Internet usage from traditional low bandwidth uses such as email etc. to more bandwidth intensive applications, such voice over IP (VoIP) and streaming audio and video.

In the past, this growth in demand for bandwidth has been limited to fiber optic and copper networks. Now this demand is also visible in the wireless market as users access the Internet over cellular connections and wireless LANs.

What data rates currently service this demand?

The 2.5G OC-48/STM-16 data rate has the lion's share of the metro market. Carriers are deploying 10G OC-192/STM-64 data rate networks. Business and technical challenges face the vendors of 10G (now) and 40G (in the future) in components and equipment arena.

Even as the current 'next generation' 10G devices are being deployed, the technology races ahead as 40G systems and components evolve from lab prototypes to real production parts. This raises some dilemmas for service providers who are considering upgrading their networks, and those who may want to preserve the value of both existing and new investments in network infrastructure.

What 2.5 G solutions currently exist?

In the 2.5G realm, SONET/SDH is king and is widely deployed in the metro and long haul networks. For the purposes of this article, any references to SONET will be applied to SDH also.

SONET is a high-speed Time Division Multiplexed (TDM) physical-layer transport technology inherently optimized for voice. With a huge installed user base to carry telephone calls around the globe, SONET also has the capacity to carry data, and several protocols have been developed to enable this data transport.
One of SONET's greatest strengths is its Automatic Protection Switching (APS) feature making SONET the transport mechanism of choice for mission-critical data. There is no Ethernet equivalent of the 2.5G data rate; one of the challenges of network service providers is carrying 1 Gigabit Ethernet traffic over SONET in the most efficient and cost effective manner possible.
The new standard of virtual concatenation solves this problem and can be used to enable provisioning of efficient 'right-sized' bandwidth for Gigabit Ethernet transport over SONET, and support dynamic reallocation of link bandwidth. Framers supporting virtual concatenation allow mapping of 2x channels of Gigabit Ethernet and up to 3 additional channels of 10/100 Ethernet over SONET OC-48, offering more than twice the efficiency of previous methods of mapping GbE over SONET.

Technical Challenges of Network Speed Migration

10G technology provides an evolutionary upgrade path from 2.5G SONET/SDH and 1 Gigabit Ethernet networks.
Most transmission impairments are related to the square of the network speed. Thus, 10G components must be 16 times more tolerant of impairments than 2.5G components. This is one of the factors that delayed the initial rollout of 10G technology in real commercial networks. 10G network components and hardware are available for operational deployment today.

Cost Challenges and Barriers to Network Speed Migration

Although technology is available to support optical networks from 2.5G and below to 40G, the real question for network operators is cost.
Current 40G technology is 10 times more expensive than 10G technology and provides only 4 times the bandwidth. Until the price of 40G technology falls to more economically feasible levels, it is unlikely to see widespread commercial deployment.

Challenge of Leveraging the Maximum Benefit from Existing Infrastructure and Supporting Multiple Standards

Infrastructure is another challenge in today's environment. There is a significant SONET/SDH infrastructure deployed in metro and long-haul applications today. Any future 10G standard needs to leverage this infrastructure to preserve the value of existing investments made by network service providers. This poses a requirement of compatibility between new 10G standards and existing 2.5G and lower speed infrastructure.
A Metro Area Network (MAN) may support multiple standards and protocols, depending on where they are used in the network. For example, in the figure below we see that both SONET and 10G Ethernet may be used in the access edge with SONET in the metro ring and SONET with DWDM in the long haul core. Lower speed SONET links may also be present, and need to interface to higher speed SONET networks. Dense Wave Division Multiplexing (DWDM) also plays a role in the metro area as it offers significant bandwidth at low cost, by multiplexing many wavelengths over a single fiber.
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Figure 1. Metropolitan Area Network (MAN) Example illustrating use of standards

Newer 10G standards are attempting to resolve this problem of compatibility with existing standards and infrastructure. The 10-Gigabit Ethernet (10GE) spec will have a WAN PHY option to enable connection of 10GE to existing and future SONET/SDH equipment, based upon the OC-192 rate. This will leverage the maximum benefit from installed SONET infrastructure, preserving the value of network providers existing investments.
Next generation components provide support for both of these standards with common interfaces and processing logic provided in one device. For example, a next-generation 10G Framer device may support Ethernet over SONET (WANPHY), Native 10G Ethernet (LANPHY), Packet Over SONET (POS) operation. An example 10G Framer is shown in Figure 2.
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Figure 2. Framer example for use with 10G SONET/SDH OC-192 and 10G Ethernet

Network Processing Challenges of Moving from 2.5G to 10G Networks
One of the challenges is that bandwidth has become a commodity while services have emerged as the real drivers of revenue.
Current programmable network processors can handle OC-48 wire rates with limited services. However, as the user adds more features to the design the NPU can quickly run out of steam.
Another challenge of today's networks is that at the aggregation point, the total bandwidth entering a system is frequently two to 12 times more then the egress point capacity. This is an oversubscribed condition requiring the use of network processing to prioritize traffic and ensure QoS.
The challenge of classification can be solved by using dedicated network co-processors to offload the additional processing burden resulting from higher data rates and additional services.
Classification engines require the use of Network Search Engines (NSEs). NSEs can help designers beat the bottleneck for forwarding lookups and other complex classification decisions.
Challenges of Higher Backplane Bandwidth Requirement
Serial transceivers are now used for high-speed, communications backplane applications. These serial connections are optimized for transmission over optical fiber, enabling communication at higher frequencies (up to 3.3 GHz) over greater distances. These devices provide high bandwidth and flexibility for applications such as backplanes for storage area network (SAN), wide area network (WAN), wireless infrastructure (WIN), and local area network (LAN) switches. Cypress's HOTLink III&#153 (High-Speed Optical Transceiver Link) portfolio of quad-channel transceivers are designed for both backplane and port applications at 2.5G and 3.125G. These devices are ideal for implementing 10G backplanes.
A serial communications system must be able to operate with the external world, and support a variety of standards such as InfiniBand&#153, Gigabit Ethernet, Fibre Channel and others. This interface between the PHY and the user's side is frequently implemented in programmable logic.
One of the challenges in implementing 10G optical backplanes is the cost of the transceivers and optical components. By using parallel optics (quad 2.5G), users may achieve considerable cost advantages over single 10G optical components.

The Silicon Light Machine (SLM) 10-Gbps (4 3 2.5-Gbps) Duplex Parallel Optical Transceiver module provides a cost effective high-bandwidth interconnect in next-generation switches and routers.

3G Base Station Transceiver Application Example

Figure 3 shows the baseband processing linecard of a 3G base station. The PHY layer serial solutions and optical transceivers sit on the interfaces on the ingress and egress to the line card. These provide the high bandwidth serial data links on both copper and optical backplanes. As 3G wireless protocols are deployed, the bandwidth required per user and on the base station backplane will increase. Optical links may be used on the backplanes and to connect base stations together over longer distances. 10 Gigabit Ethernet or proprietary 10G protocols can be implemented using the quad channel serial devices described earlier.

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Figure 3. 3G Base station card

What Other Challenges Exist in the Wireless Market?

Providing the bandwidth to service wired and mobile multimedia communications is only part of the wireless challenge. These mobile terminals need to offer a sufficiently low power consumption and long standby and usage time to satisfy consumers' demands of Internet access anytime. Cypress's memory products offer a better power performance at a lower cost enabling customers to manufacture handsets with a longer battery life than its competition.

Another challenge is making wireless products connect easily with wired infrastructure. Cypress offers USB and Bluetooth solutions to make the use of mobile multimedia products easier and more appealing to consumers. These new wired and wireless interface products will greatly increase the value of the 2.5G and the multimedia 3G handsets.

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