The New Age MAN – The Architectures and Services

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The Marketplace Void

The growth in the capacity of the typical Local Area Network (LAN) over the last few years has been explosive. It is now common to connect desktops into a wiring hub using dedicated Ethernet running at either 10 or 100 Million bits per second (Mbps). It is also common to interconnect these wiring hubs with dedicated Ethernet running at either a 100 or a 1000 Mbps.

At the same time that the capacity of the LAN has exploded, there has been continued deployment of higher capacity fiber optics in the deep core of the Wide Area Network (WAN). However, to date there has been a void in the marketplace relative to a similar increase in the performance of services in the Metropolitan Area. If we look at just the access services between a company's location and the Point of Presence (PoP) of its network service provider, these services can be characterized as being very expensive, highly subject to failure, and time consuming to provision.

However, there has been a lot of discussion recently about how new aged Metropolitan Area Network (MAN) services will fill this marketplace void. In order to see how well these new aged services can live up to the hype, the authors worked with a number of MAN service providers, including both incumbent and emerging service providers. Our goal was to get a thorough understanding of the services that they were offering for transporting IP over Ethernet traffic on a site-to-site basis.

With more organizations interested in running complex applications, such as ERP and CRM, over the WAN and new applications such as video conferencing and streaming video looming on the horizon, the authors believe that any new age access services need to offer more than just cheap bandwidth. These services need to also deliver the reliability, security, manageability, and flexibility that enterprises have come to expect of the traditional WAN access services, built on the SONET/SDH infrastructure.

What we found was fascinating. While there are a large number of service providers offering MAN services, there are more differences amongst the approaches taken by these service providers than there are similarities. This article is the first of a two article series intended to help the reader choose between the wide range of choices currently available in the marketplace.

In this article we will cover a high-level overview of the types of services being offered by these service providers. This article will also detail the primary network architectures being deployed by MAN service providers. The second article will focus on the market place demand for these services as well as other key issues that determine if these services are indeed ready for production networks. These issues include the manageability of these new services, as well as whether or not you can expect to get meaningful Service Level Agreements (SLAs) on these services. That article will also provide some insight into whether or not these services provide a breakthrough in the pricing of MAN services.

The History of MAN Revisited

In the mid 1990s we saw the first significant attempt at delivering MAN services. This attempt resulted in the deployment of Transparent LAN Services (TLS) based on ATM/SONET/SDH. These managed TLS services failed to catch on for a number of reasons. One of these reasons was that these services were more focused on masking the complexity of the WAN, than on reducing the cost per Mbps, or addressing the problem of long lead times for additional bandwidth. Additional reasons for the lack of success of these services is that in the mid 1990s Ethernet was not as robust a technology as it currently is, and there was not any where near as much optical fiber in the ground as there currently is.

Now a number of CLECs and ILECs are trying again to eliminate the bandwidth bottleneck in the metropolitan area, this time by extending optical technologies from the LAN and/or the WAN Core into the MAN. As shown in Figure 1, these new MANs can potentially replace all the connectivity provided by the traditional local loop. This includes:

- Site-to-Site in the Metropolitan Area
- Access to the Internet or ISP
- Access to WAN services between Metropolitan areas

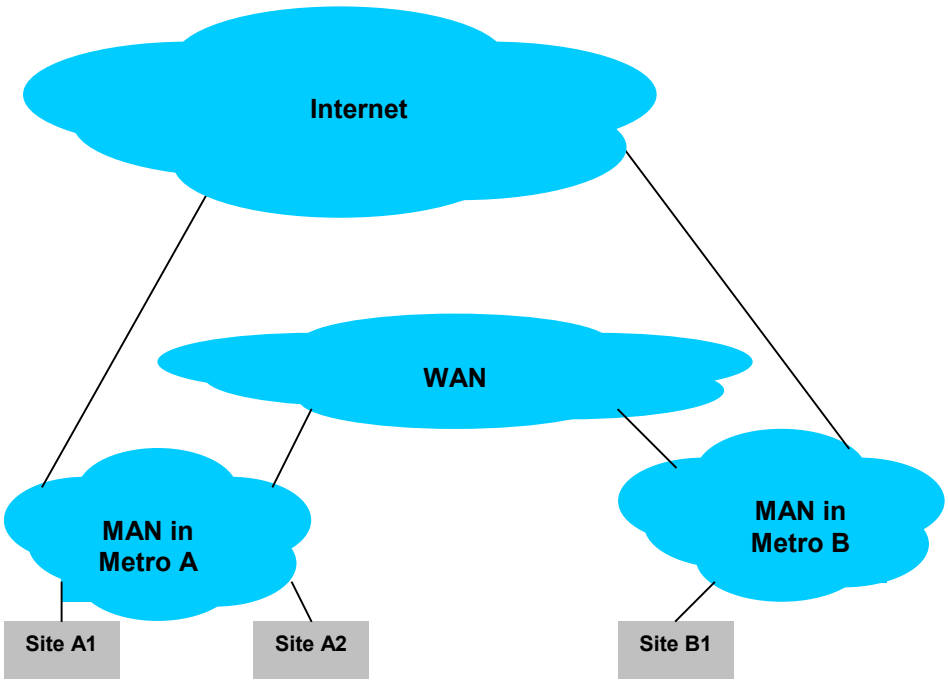

Figure 1: MAN Services

One common requirement of MAN access solutions with bandwidths of 100 Mbps and higher is that an optical fiber must be available to connect the enterprise location with the Service Provider's PoP. This explains why most MAN Service Providers are focused on dense concentrations of large, often multi-tenant, office buildings where fiber may already be available, or where the installation costs can easily be justified.

MAN Technologies

The coalescence of LAN and WAN technologies in the MAN may well result in a simpler, more homogeneous end-to-end LAN/MAN/WAN network optimized for high-speed data traffic. That follows because the improved simplicity of the new aged MANs allows the Service Provider to offer much lower cost per Mbps, plus quicker provisioning to allow the user to deploy just-in-time capacity expansion.

The primary LAN-derived technologies being deployed in the MAN include:

- Long-haul Ethernet over dark fiber: 100Base-LH and 1000Base-LH
- Coarse Wavelength Division Multiplexing (CWDM)
- 10 Gigabit Ethernet

The WAN Core is also contributing a number of significant technologies to the Metro.

- Dense Wavelength Division Multiplexing (DWDM)
- Optical amplification
- IP Packet over SONET/SDH
- IP Packet over DWDM
- Packet Ring Technology (Standards work in process)
- MPLS and MP λ Switching

Hardware vendors are packaging various combinations of these technologies in a wide range of Service Interface Units (SIUs). SIUs are the Service Provider-managed CPE to which enterprise routers and switches connect for MAN services. SIUs fall into two general categories:

- Ethernet MAN switches. These might be Layer 2/Layer 3 LAN switch designs that have been adapted for the MAN by the incorporation of LH Ethernet and/or CWDM.

- DWDM shelves with Optical Add Drop Multiplexer (OADM) functionality and varying degrees of Time Division Multiplexing (TDM), IP switching and SONET or optical protection functionality.

MAN Architectures

In evaluating different MAN services it is worthwhile to develop a good general understanding of the MAN architectures that competing vendors are deploying. The architecture and the underlying technologies dictate the key characteristics of the services that can be offered. This includes flexibility to support new applications, bandwidth scalability, cost, reliability, security, manageability, quality of service, and ability to provision bandwidth rapidly. The most important aspects of MAN architecture for users to focus on are the capabilities of the managed CPE and SIUs and the related equipment in the PoPs used to connect the site to the MAN and the MAN to other WAN services.

Figure 2 shows the architecture for a Transparent LAN Service (TLS) based on ATM and SONET/SDH. The TLS is traditional MAN service that has been available from the ILECs, such as SBC and others. The Ethernet traffic from Site A1 is encapsulated in accordance with RFC 1483 and bridged over the ATM network to Site A2. A PVC would be configured for each pair of sites in the MAN. Scalability and cost are determined by the ATM/SONET/SDH equipment, with SONET protection plus redundancy in the PoP eliminating single points of failure in the MAN itself. With a dedicated PVC and SIU for each customer site, security is equivalent to that of an ATM network service.

For Internet and WAN connectivity additional routed ports would have to be configured on the site router/switch, and additional PVCs established to the ISP and the provider of routed IP backbone services.

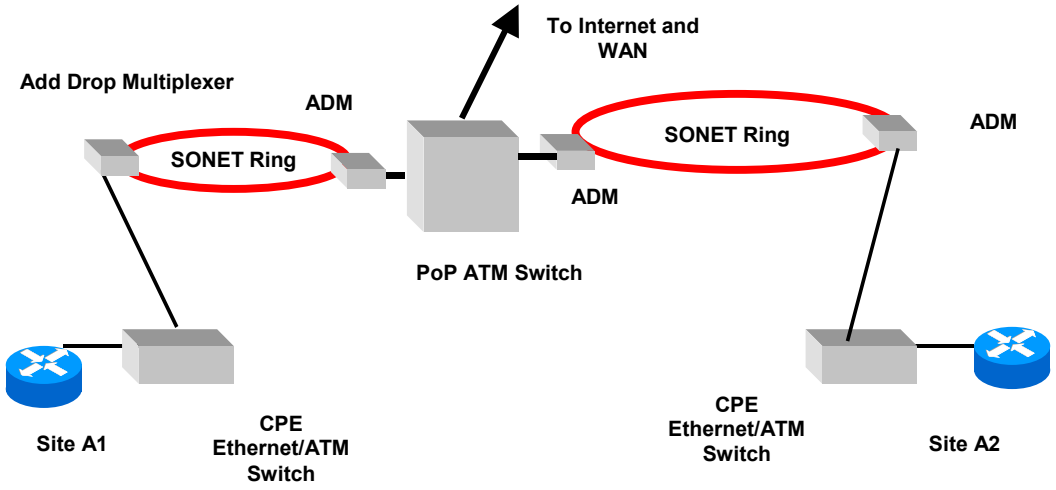

Figure 2: MAN based on ATM/SONET/SDH TLS

A much simpler and more homogeneous MAN architecture based on Long Haul Ethernet and Ethernet Layer 2/3 switches is shown in Figure 3. This class of architecture is one option for some of the MAN CLECs, such as Telseon. In this example, the SIU at site A1

could be dedicated to a single subscriber or shared by a number of subscribers in a large multi-tenant building. In either case, the MAN traffic of each subscriber is encapsulated with a unique 802.1Q VLAN header and bridged over the MAN. As with the TLS, additional routed ports would be configured for Internet Access and WAN services.

Scalability is provided by the long haul versions of Fast Ethernet and Gigabit Ethernet, while 10 Gigabit Ethernet and future generations of Ethernet will have inherent long reach characteristics. Reliability of the MAN is made roughly comparable to that of the SONET-based TLS through the use of meshing and redundant links, with fast spanning tree failovers in the event of link failures. Where the security offered by VLANs is not considered adequate, IT organizations may well decide to deploy firewalls and other security functionality at the appropriate sites.

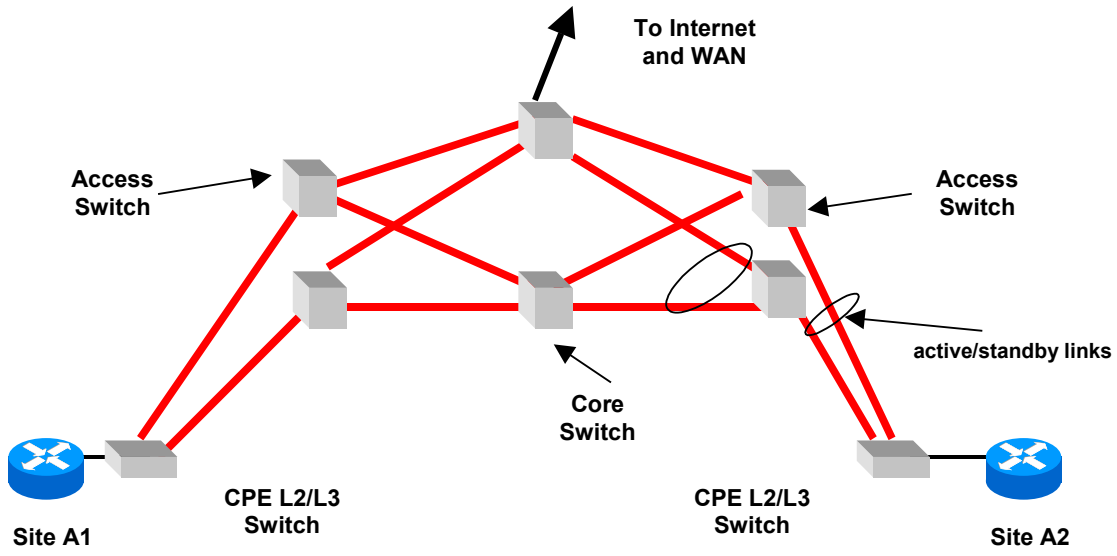

Figure 3: MAN based on IP over Long Haul Ethernet

Because of the scarcity of optical fiber in the last mile to customer sites, equipment vendors have been integrating CWDM and proprietary packet ring technology in their Ethernet MAN switches. CDWM provides either 4 or 8 wavelengths over each fiber strand, compared to up to 32 or 64 wavelengths in the case of DWDM. A dual, self-healing Ethernet ring is used to daisy-chain among the customer sites with the CPE MAN switch providing add/drop functionality.

Most of the other characteristics of the CWDM Ethernet MAN are similar to the point-to-point Ethernet MAN described earlier. The CPE MAN switch may be shared in a Multi-Tenant Unit (MTU), MAN traffic is bridged with a VLAN or VMAN per subscriber, with additional routed ports required for Internet Access and routed WAN services. Examples of MAN CLECs exploiting CWDM technology include Yipes and (more recently) Telseon

While there are a number of proprietary packet ring implementations, the IEEE is working on a Resilient Packet Ring (RPR) standard IEEE 802.17. 802.17 will be optimized for Ethernet frames and is intended to deliver availability similar to that of a SONET ring over either dark fiber or WDM. A notable pre-standard technology being considered by the IEEE is Cisco's DPT 622 Mbps ring network based on the Spatial Reuse Protocol (SRP), a Cisco-developed MAC-layer protocol for ring-based packet Internetworking that is self-healing and has a recovery time of less than 50ms. SRP and 802.17 are both intended to provide higher bandwidth efficiency and better support for meshed topologies than SONET can deliver with its more rigid TDM structure.

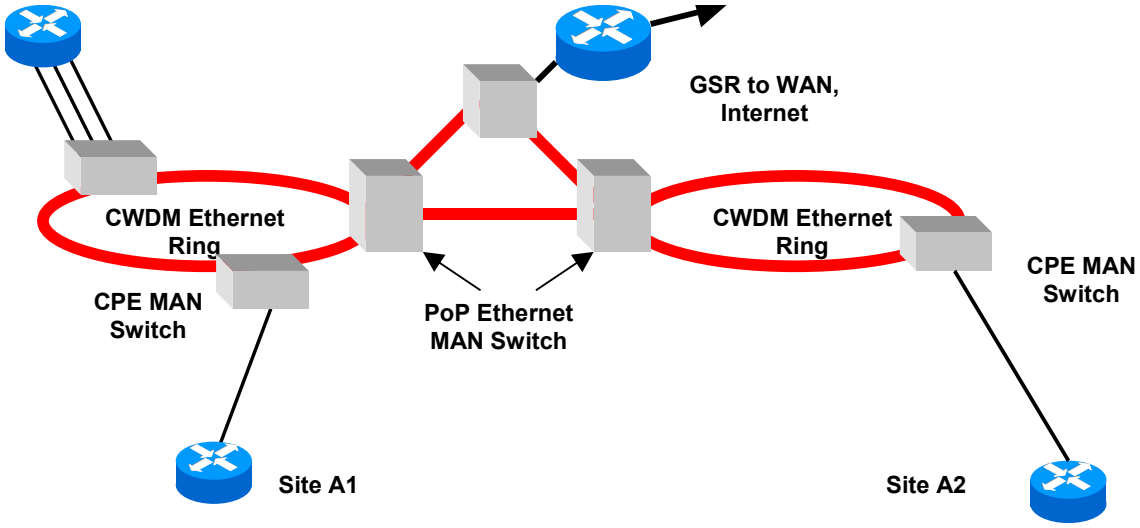

Figure 4: MAN based on IP over Long Haul Ethernet and CWDM Rings

Another class of MAN architectures is based on DWDM rings linking Optical Add Drop Multiplexers (OADM). Due to the overpopulation of the market for optical networking products, OADMs come in lots of flavors.

The primary difference among OADMs is how much support for SONET is provided. Among the possibilities are to support SONET framing, SONET protection/restoration, and/or SONET TDM/ADM functionality. SONET support is very important for ILECs who require backward compatibility with their TDM infrastructures and also for CLECs who are interested in offering traditional WAN access (e.g., Frame Relay and T1 leased lines) in addition to 10/100/1000 Ethernet MANs and other high bandwidth services. A greenfield carrier who focuses DWDM entirely on Ethernet MANs, could presumably minimize the cost of the infrastructure by avoiding SONET support altogether. The combination of flexibility and scalability of DWDM-based MANs has attracted a wide range of incumbent and greenfield MAN vendors, including Verizon, GiantLoop, Cogent, LightWave Communications, XO Communications, and GigX Communications. Other ILECs are expected to follow suit.

Another key difference among OADMs is whether they allow a number of subscribers for non-traditional services to share the bandwidth provided by a single wavelength (e.g., ten Gigabit Ethernet channels over a single λ at OC-192). If a λ must be dedicated to a single subscriber, the rest of the potential bandwidth of the wavelength is essentially wasted. One approach is to allocate a λ to a type of service, such as Ethernet, by switching traffic from multiple users over a single channel with MPLS or VLAN tagging of subscriber packets. Among other solutions is to groom multi-service traffic for transport over a single λ using SONET or non-SONET TDM.

A third area of OADM differentiation is the way that protection is delivered to non-SONET services. One approach is to extend SONET's protection to other services. However, DWDM itself can provide 1:1 protection at the optical level for Ethernet and other services by holding a λ in reserve as a backup for each primary λ. Another possible DWDM approach is to use 1:n protection with a single λ backing up n primary λs.

One key aspect of the DWDM physical layer is that a wavelength and the on-off keying (OOK) of the light beam to modulate the signal are quite indifferent to the upper layer protocols. Therefore, a single optical interface card on the OADM can provide native transport for a number of LAN or SAN technologies that are clocked in the same speed range. Hence, many OADM implementations can transport a wide range of optical traffic types, including SONET/ATM, Ethernet, Fibre Channel, ESCON, FICON and other proprietary protocols used by remote storage services and remote CPU backup or clustering services.

For the larger customer, a MAN based on DWDM can offer the possibility to lease an entire wavelength to connect two sites in the MAN or even two MAN-attached sites separated by thousands of miles. The maximum capacity would be determined by the optical bandwidth of the MAN or the MAN/WAN network, and the customer could use the bandwidth in whatever way they wish, such as Gigabit Ethernet during business hours and ESCON at night for remote backups or database synchronization. A λ service also provides an enhanced level of security over packet-based or circuit-based services because of the added difficulty of intercepting or tapping optical signals.

Figure 5 represents a DWDM MAN implementation where the inter-PoP, and in this case the wide area network connectivity, is provided by a mesh of IP GSRs. For a λ DWDM service, the site routers or other networking equipment, such as a SAN switches would be directly connected to the OADM and the GSRs would be replaced with a long-haul DWDM network to convey the λ site-to-site.

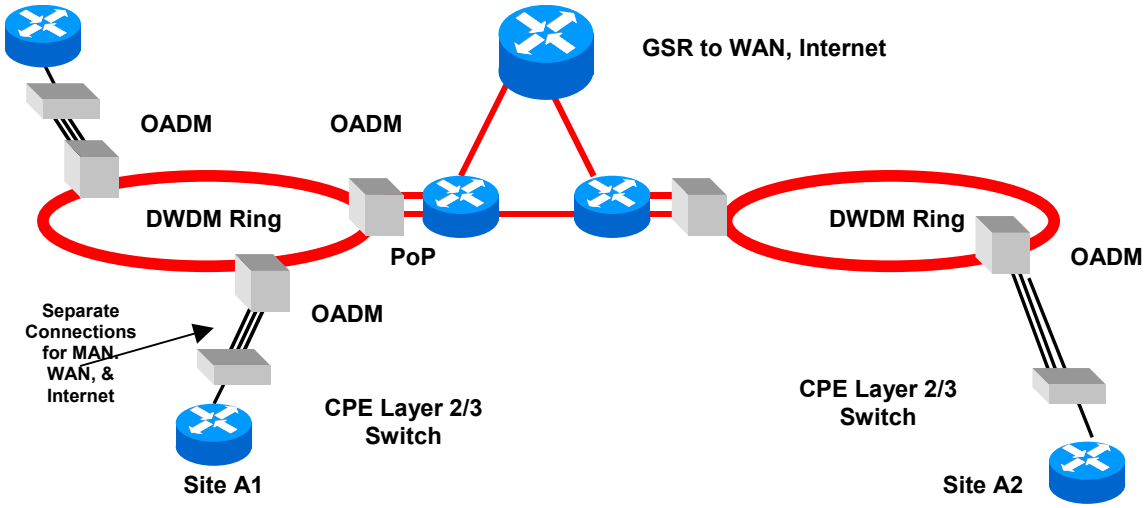

Figure 5: MAN based on IP over DWDM Rings