The Metro Ethernet Network

Comparison to Legacy SONET/SDH MANs for Metro Data Service Providers

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Abstract

This paper focuses on the results of a study commissioned by the MEF to quantify how Ethernet-over-fiber and next-generation SONET/SDH-based architectures afford the operational simplicity, data transport efficiency, and scalability required to offer service providers a superior return on investment (ROI). The study finds that the Ethernet based service solutions provide a 49 percent operational expense and 39 percent capital expense savings as compared to legacy SONET/SDH solutions. Lastly, this paper offers explores how service providers can increase service revenue by offering a comprehensive suite of flexible, granular, and affordable metro Ethernet services easily tailored to meet the dynamic requirements of enterprise customers.

INTRODUCTION

The explosion of Internet traffic and IP services is driving order of magnitude increases in bandwidth demand across service provider networks on an annual basis. This explosion is propelled by widespread availability of broadband access technologies and by increasingly bandwidth-intensive multimedia applications. This paper will show that Optical Ethernet solutions provide service providers a number of key technology benefits to handle these increases compared to existing solutions.

The essential problem is that the majority of today's metro area networks (MANs) are built on legacy SONET/SDH ring infrastructures. Optimized for slow-growing, narrowband, circuit-switched voice traffic, these networks lack the dynamic functionality and rapid scalability needed to keep pace with the increasing volumes and unpredictability of data traffic. Legacy SONET/SDH networks have a number of limitations when used for data applications because of the time and resources needed to provision in a high-growth data environment ("People"); inefficiency for data transport ("Pipes"); and prohibitive expense to scale ("Ports").

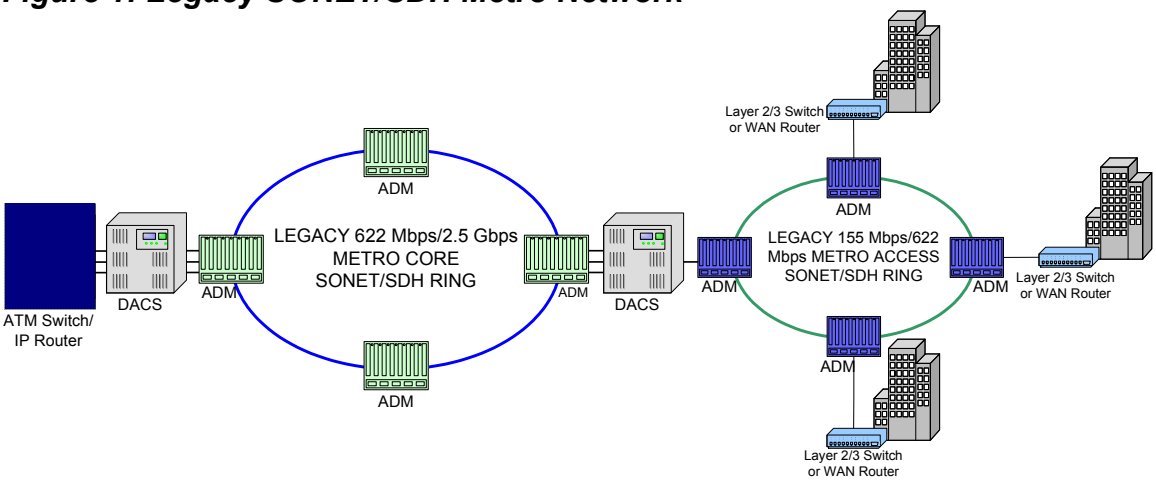
Intent on overcoming these "People, Pipes, and Ports" constraints, service providers are turning to alternative Optical Ethernet network architectures purpose-built for the new data-centric environment. Optical Ethernet supports the delivery of a full suite of carrier-class Ethernet services up to 1 Gbps. It also provides for integrated optical transport, switching, and statistical multiplexing to help reduce the number of devices and capital expenses in the MAN. Finally, Optical Ethernet provides bandwidth-on-demand service provisioning capabilities.

This paper will focus on how Ethernet-over-fiber and next-generation SONET/SDH-based architectures afford the operational simplicity, data transport efficiency, and scalability required to offer service providers a superior return on investment (ROI). It will also describe the **49 percent operational expense and 39 percent capital expense advantages these solutions have compared to legacy SONET/SDH,** based on a business case study provided by Network Strategy Partners (NSP), on behalf of the MEF. Lastly, this paper will explain that service providers can increase service revenue by offering a comprehensive suite of flexible, granular, and affordable metro Ethernet services easily tailored to meet the dynamic requirements of enterprise customers.

LEGACY SONET/SDH MANS: ILL-SUITED FOR TODAY'S REQUIREMENTS

The typical legacy SONET/SDH MAN architecture consists of metro core and metro access rings interconnected by a combination of SONET/SDH add/drop multiplexers (ADMs) and digital access cross-connect systems (DACS). The voice-optimized nature of this network means that data traffic requires additional switches or routers to map data into time division multiplexed (TDM) channels for transport across the SONET/SDH network. The result is a complex, multi-tiered, hierarchical architecturally constrained network, ineffective for data-centric metro environments.

Figure 1: Legacy SONET/SDH Metro Network



"People" Constraints: Personnel costs make up a majority of operational expenses (OPEX) and relate to three basic operational functions. Engineering and operational support relates to design, configuration, deployment and maintenance of separate SONET/SDH, ATM and IP networks. Fault isolation and diagnosis relates to troubleshooting a fault through a complex, hierarchical network. Service provisioning consists of the manual re-configuration required of network elements at all layers. This function includes truck rolls, multiple technicians, and customer port and platform upgrades.

"Pipes" Constraints: Data transport is characterized by a lack of statistical multiplexing functionality meaning data transmissions are forced into rigid 51.84 Mbps STS-1/VC-4 increments even though they often occupy less than 20 percent of the available bandwidth. This leads to scalability problems requiring either upgrading existing rings via forklift change-outs of all infrastructure components, or adding dark fiber to deploy additional rings with additional equipment.

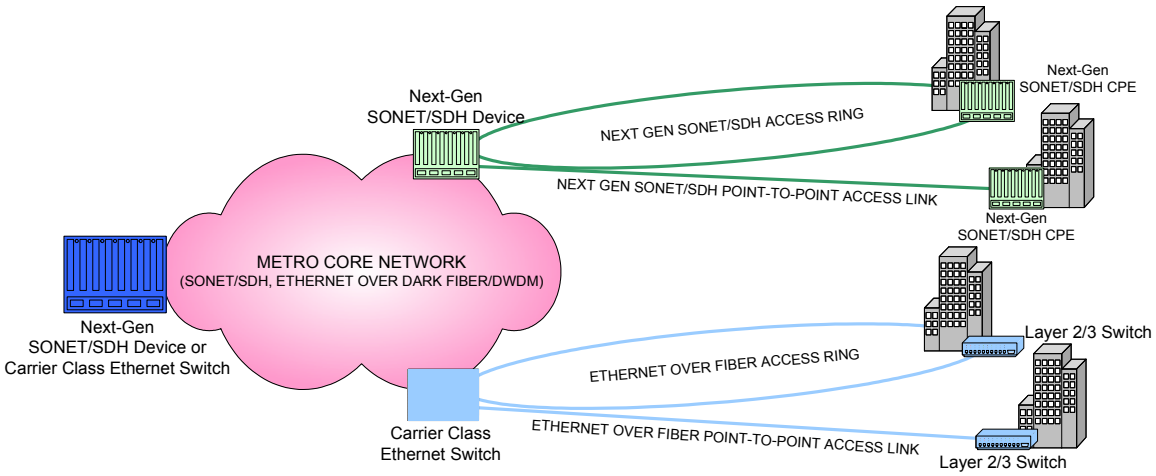
"Ports" Constraints: Having to procure redundant Layer 1, 2, and 3 devices to design and build-out a fully fault-tolerant metro network adds substantial capital expenditures (CAPEX) to ATM or IP over SONET/SDH MANs. For proof, one need only look at the average selling price per gigabit of bandwidth for legacy SONET/SDH gear that ranges from $10,000 to $35,000, depending on port speed.

THE METRO ETHERNET NETWORK: PURPOSE-BUILT FOR TODAY'S REQUIREMENTS

Two alternative architectures based on the successful fusion of optical and Ethernet technologies — collectively referred to as Optical Ethernet — have recently emerged to address the shortcomings of legacy SONET/SDH in today's metro network *(Figure 2)*. Purpose-built for data transport, Ethernet-over-fiber and Next-Generation SONET/SDH-based MANs combine the familiarity and ubiquity of Ethernet networking with the speed of optical transport to overcome capacity bottlenecks and alleviate OPEX and CAPEX constraints.

Both approaches are characterized by delivery of a full suite of carrier-class Ethernet services, native Ethernet (10 Mbps, 100 Mbps, and/or 1 Gbps) customer hand-offs provisionable in granular 1 Mbps and below increments and integrated optical transport, Ethernet switching, statistical multiplexing functionality, along with bandwidth-on-demand service provisioning capabilities.

Figure 2: Metro Optical Ethernet Network



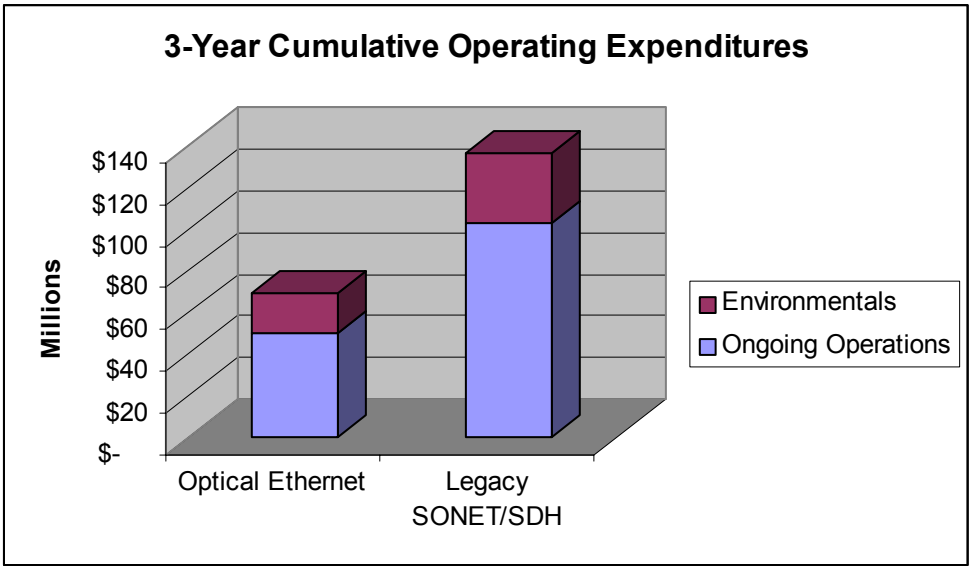
"People" Advantages: Reduced engineering and operational support costs are the result of managing fewer layers. Simplified fault isolation and diagnosis is achieved because fewer elements have fewer possible points of failure and less frequent faults that are easier to pinpoint. Dynamic point-and-click service provisioning combines advanced element management systems (EMSs) and software-provisionable rate limiting techniques to simplify the provisioning of service bandwidth upgrades, eliminate truck rolls, and reduce manual configuration errors.

To explore this, a case study was conducted by NSP titled, The Business Case for Optical Ethernet vs. Legacy SONET/SDH in a Metro Service Provider Data Network for the MEF. It built a model based on the three-year build-out of a medium-sized metro area network to 100s of small business to large enterprise customers more tangibly illustrates these advantages. Two distinct networks are designed to deliver

Ethernet services to the same customer base — a legacy SONET/SDH-based network and a network based on Optical Ethernet design principles. The topology used for both consists of four (4) metro core POPs, a 10 Gbps logically-meshed metro core ring, and nx1 Gbps metro access rings or spurs

The business case model, as detailed in the NSP case study, reveals **a $68 million or 49 percent operating expenditures savings for the network based on Optical Ethernet design principles** versus the more traditional legacy SONET/SDH-based network *(Figure 3).*

Figure 3: Optical Ethernet Operating Expenditure Savings



"Pipes" Advantages: Due to a data optimized design and an easily scalable infrastructure, Metro Ethernet Networks also offer clear-cut "pipes" advantages for data transport. Efficient data transport techniques of transporting Ethernet directly via optics, combine with statistical multiplexing and other packet optimization techniques allow more efficient transport of IP traffic in similarly sized packets. Economical scalability means forklift upgrades and wholesale platform change-outs are unnecessary since upgrading capacity typically involves only adding an inexpensive Ethernet port or upgrading to a higher Ethernet port speed.

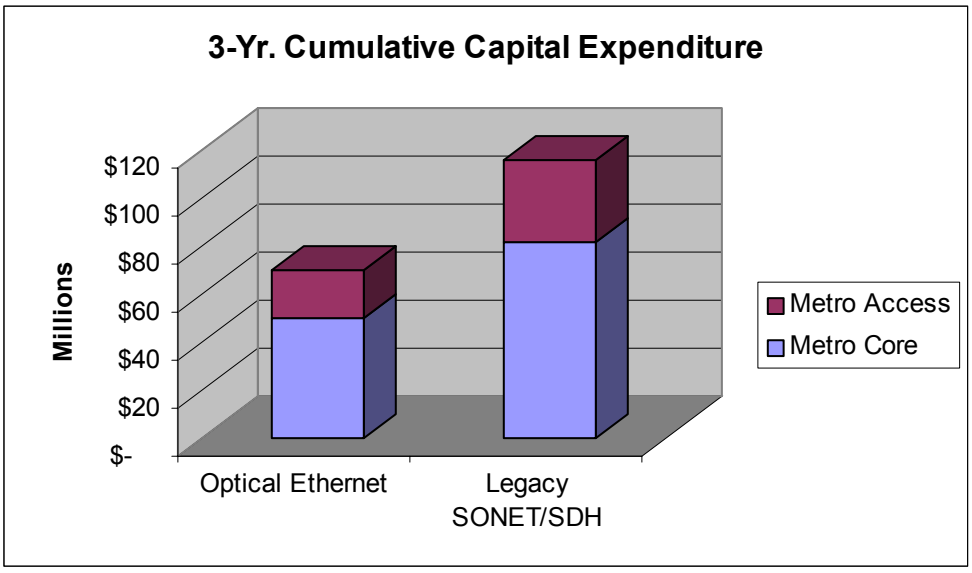
"Ports" Advantages: Optical Ethernet enables cost effective network build-outs since Optical Ethernet requires less equipment in general to turn up data services. Multiple devices at the physical and data transport levels can be collapsed into a single network element.

In addition, research shows that the use of Ethernet ports provides up to a 91% CAPEX savings compared to SONET/SDH because Ethernet interfaces are typically 25 percent to 40 percent less expensive per Mbps of bandwidth than lower speed TDM and ATM ports. According to recent, independent studies conducted by both

Gartner Group and Yankee Group, Ethernet switching costs will continue to decrease approximately 30 percent annually.

Our case study model illustrates these savings in a more meaningful hard dollar example. Using configurations designed to meet forecasted service demand, capital expenditures are calculated in detail down to the line card for the metro core and metro access portions of the network. All equipment configurations include chassis, line cards, switch fabrics, power supplies and management software. Sparing costs are also included. Analysis of these calculations reveals that a medium-sized metro network based on the design principles of **Optical Ethernet can generate capital expenditure savings in the metro core and access networks of $46 million or 39 percent** over a legacy SONET/SDH-based solution during a three-year period *(Figure 4).*

Figure 4: Optical Ethernet Capital Expenditure Savings



METRO ETHERNET NETWORKS: INCREASED SERVICE REVENUE OPPORTUNITIES

Beyond these "People, Pipes, and Ports" efficiencies, the metro Ethernet network also provides increased service revenue opportunities in the huge gaps created by the TDM hierarchy. Optical Ethernet enables service providers to capture pent-up demand for intermediate bandwidth between legacy service tiers with a robust suite of flexible, scalable, and highly granular metro Ethernet services.

Metro Ethernet Private Line Services are an alternative to present private line and Frame Relay services. Now standardized by the MEF as Ethernet Line or "E-Line",

services can provide the same dedicated bandwidth and unparalleled security but over a standard Ethernet interface. E-Line is scalable from 1 Mbps to 1 Gbps in granular 1 Mbps increments. Similar to Frame Relay, E-Line can allow be configured to allows enterprise customers to subscribe to and self-adjust guaranteed committed information rates (CIR) and committed burst sizes (CBS). Peak information rates (PIRs), and peak burst sizes (PBS) allow customers to burst at negotiated levels beyond the CIR/CBS (up to the physical port speed). Performance-related service-level agreements (SLAs) such as network availability, roundtrip latency, and packet loss can also be offered.

Ethernet LAN Services likewise are similar to legacy Transparent LAN services. Now standardized by the MEF as Ethernet LAN or "E-LAN" services provide any to any LAN-to-LAN metro Ethernet connectivity over shared network resources. E-LAN has the same standard Ethernet interfaces and scalability as well as the same CIR, CBS, PIR, PBS and SLA offerings as E-Line.

Another important strategic benefit for the service provider is the dynamic provisioning feature allowing the enterprise customer to subscribe to the exact capacity they require. For the service provider, this ability can unleash revenue locked up in the thousands of DS-1/E1 and DS-3/E3 back-orders and speed time to revenue.

CONCLUSION

Ethernet over fiber and Next Generation SONET/SDH Optical Ethernet technologies provide distinct operational, strategic and economic advantages over legacy SONET/SDH for the delivery of metro data services. By combining the simplicity and scalability of Ethernet networking technology with the speed of optical transport, Optical Ethernet networks overcome the primary limitations of legacy SONET/SDH data networks.

Specifically, these advantages are reduced engineering and operational support costs, simplified fault isolation and diagnosis, dynamic point-and-click service provisioning, more efficient data transport, economical scalability, cost effective network build-outs, and new service revenue opportunities.

Leveraging these benefits, service providers can significantly reduce operational and capital expenditures and boost profitability with a future-proof infrastructure that will scale smoothly to meet escalating metro capacity demands.

See the case study detail, in The Business Case for Optical Ethernet vs. Legacy SONET/SDH in a Metro Service Provider Data Network …… for full further information on the numbers and assumptions referenced in this whitepaper.

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About the Metro Ethernet Forum

The Metro Ethernet Forum (MEF) is a non-profit organization dedicated to accelerating the adoption of optical Ethernet as the technology of choice in metro networks worldwide.

The Forum is comprised of leading service providers, major incumbent local exchange carriers, top network equipment vendors and other prominent networking companies that share an interest in metro Ethernet. As of March 11, 2002, the MEF has 70 members.

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