Total Cost of Ownership Analysis of Matisse Networks EtherBurst Optical Switch

Network Strategy Partners, LLC

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Executive Summary

Metro aggregation networks are migrating toward Ethernet optical transport in response to the market acceptance and growing demand for Carrier Ethernet and Triple Play service offerings. Ethernet optical transport is an attractive solution to Metro aggregation networking needs because it more easily accommodates customer interfaces, explosive bandwidth demand growth, and volatile traffic patterns.

Metro optical transport is implemented today using a combination of Ethernet switches and ROADMs (Reconfigurable Optical Add Drop Multiplexers.) Though Ethernet switches and ROADMs are conceptually well suited to accommodate high bandwidth and unpredictable traffic characteristics, current product implementations limit Ethernet interfaces to 10 Gbps bandwidth and ROADMs to dependence on circuit-based designs.

Matisse Networks' EtherBurst Optical Switch overcomes these product limitations by employing optical burst switching technology to scale metro Ethernet aggregation network bandwidth up to 640 Gbps.

This paper compares the Total Cost of Ownership (TCO) of a ROADM architecture to an EtherBurst architecture for Ethernet optical transport. TCO for three scenarios are analyzed.

1. Carrier Ethernet services
2. Triple Play services
3. Carrier Ethernet and Triple Play services combined – a converged scenario

Network designs using the two alternative optical transport architectures are developed for a hypothetical network that is representative of a metro area and used to compute TCO for a five-year study period.

The TCO comparison finds:

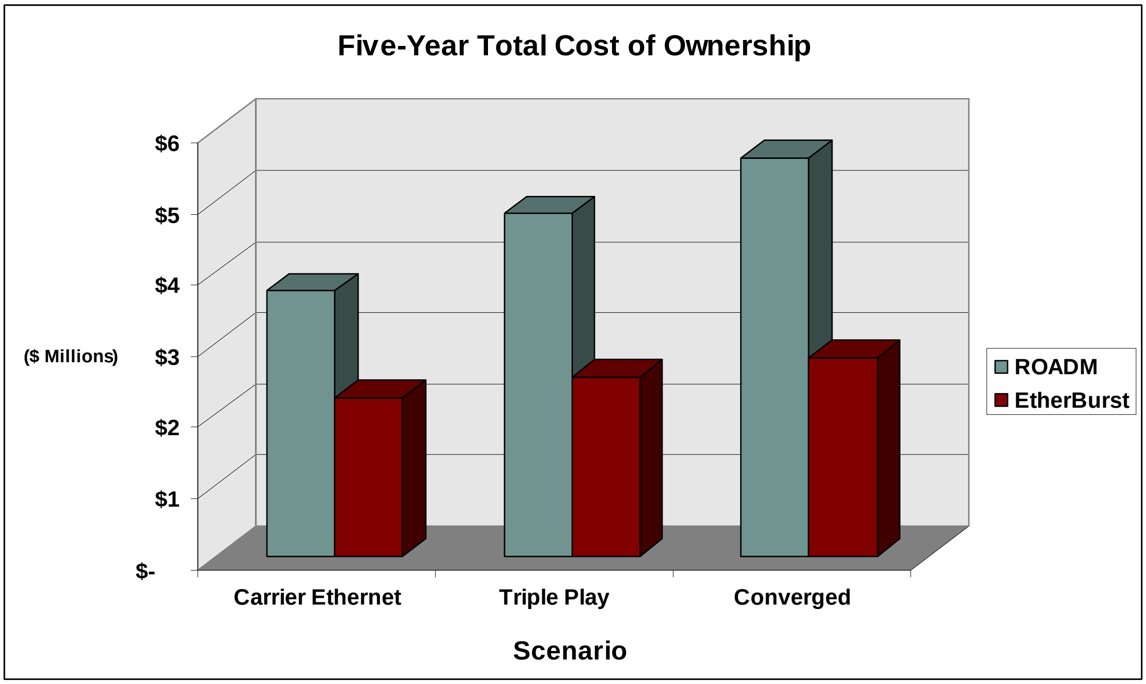
- EtherBurst has 40% less TCO for the optical systems in a metro aggregation network dedicated to Carrier Ethernet services.
- EtherBurst has 48% less TCO for a metro aggregation network dedicated to Triple Play service delivery.
- EtherBurst has 50% savings when delivering both Carrier Ethernet and Triple Play services together.

As bandwidth demand scales to 10Gbps and beyond, the relative savings of EtherBurst continues to increase when compared against ROADM systems for metro Ethernet optical transport networks. CapEx savings are primarily due to optical burst switching's more efficient utilization of optical transport capacity for packet services. With EtherBurst, relative utilization is further increased by finer-grain QoS and more efficient handling of multicast traffic. OpEx reduction is due to the relative ease of provisioning,

managing and maintaining packet optical transport with EtherBurst, which results from the elimination of planning, provisioning and reconfiguring optical circuits.

Figure 1 summarizes the TCO results for the three scenarios.

Figure 1
Five-Year Total Cost of Ownership



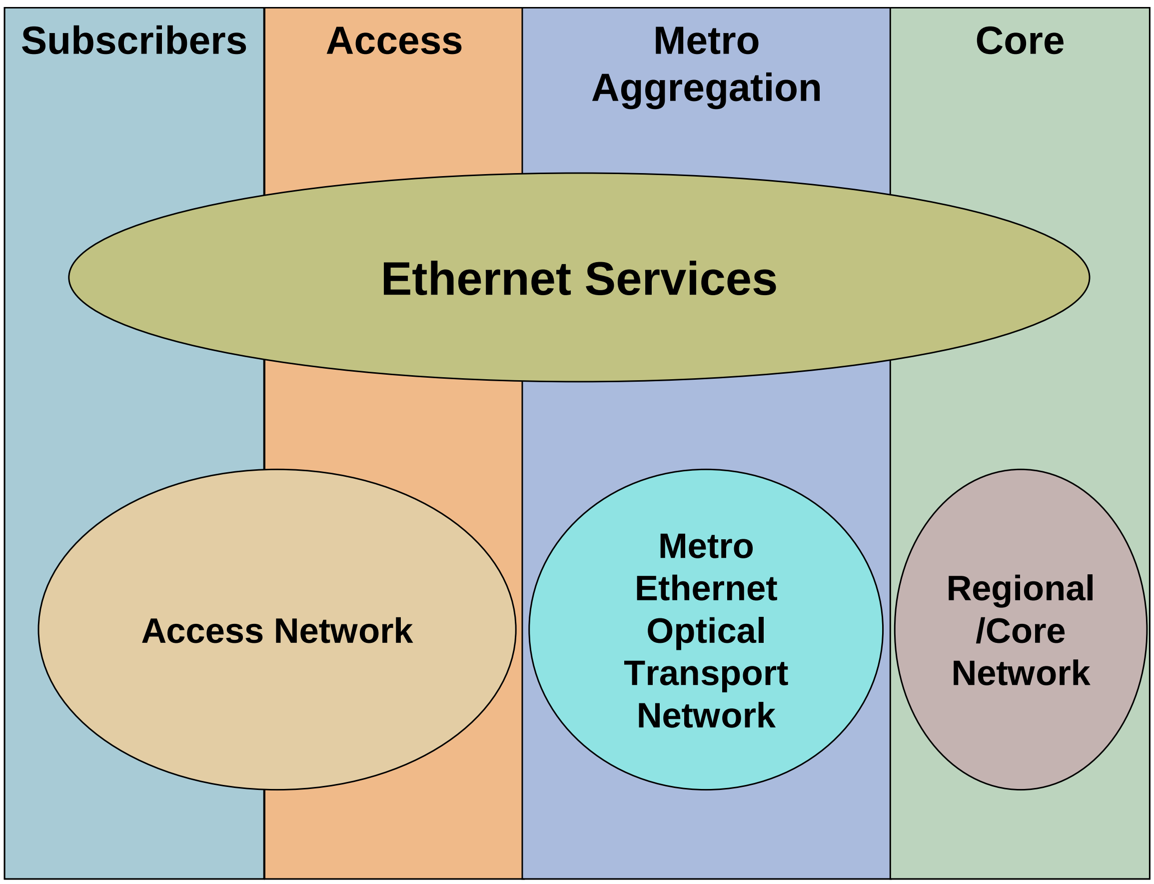
In addition to these savings, the associated switch/router architecture is simplified, and fewer 10GE ports are required as a result of EtherBurst's integration of layer2 intelligence into the optical transport.

Introduction

Metro aggregation networks are migrating toward Ethernet optical transport networks to more easily accommodate explosive growth in metro bandwidth demand and unpredictable metro traffic patterns. Increasing market acceptance and deployment of Carrier Ethernet and Triple Play service offerings are the root cause of this rapid and volatile growth in metro aggregation network traffic.

Figure 2 depicts the role of the metro aggregation network in delivering end-to-end Ethernet services.

Figure 2
End-to-End Ethernet Service Delivery



Ethernet services are used to form retail offerings such as Carrier Ethernet services sold to enterprise customers and as a service delivery vehicle for retail services such as video. The physical networks underlying end-to-end Ethernet services consist of three separate elements—Access, Metro Aggregation and Core. Ethernet technology increasingly is being used for all three networks. The access network connects subscribers—who almost universally use Ethernet LAN technology—to local access systems where Ethernet DSLAMs are becoming a common means of connecting subscribers to Central Offices (Wire Centers). The Metro Aggregation network in turn connects individual Central

Offices to the Core Network. This aggregation network which is the focus of this paper is moving toward use of Ethernet and optical transport equipment where the state-of-the-art consists of Ethernet Switches and ROADMs (Reconfigurable Optical Add Drop Multiplexers). We refer to this as the Metro Ethernet Optical Transport Network. The Core Network provides regional connections as well as world-wide backbone connectivity. Today, the Access and Metro Ethernet Optical Transport Networks typically employ layer 2 Ethernet switching technology while the routers at the edge of the Core network provide a multi-service interface to MPLS networking services (layer 2 and layer 3). Since MPLS capable technology is more expensive than pure layer 2 switching efficiently aggregating layer 2 Ethernet traffic before it reaches the core is important for overall network efficiency.

Though Ethernet and ROADM technologies are conceptually well suited to accommodate very high bandwidth, current product implementations limit Ethernet to 10 Gbps bandwidth and ROADMs to dependence on circuit-based designs.

Matisse Networks' EtherBurst Optical Switch overcomes these product limitations by employing optical burst switching technology to scale metro aggregation network bandwidth up to 640 Gbps.

This whitepaper compares the Total Cost of Ownership (TCO) of a metro Ethernet optical transport network for two alternative architectures—ROADM and EtherBurst Optical Switch.

Three scenarios are analyzed for a metro aggregation network supporting the following services:

1. Carrier Ethernet services
2. Triple Play services
3. Carrier Ethernet and Triple Play services combined

The analysis employs a hypothetical metro aggregation network that represents a composite of the types of networks service providers are deploying today with service and traffic projections based upon current market research data.

Network designs using EtherBurst and ROADM architectures are developed for the hypothetical network over a five-year study period. The CapEx and OpEx for each architecture is calculated and used in the TCO analysis. The analysis emphasizes quantification of TCO reductions and the sources of these savings.

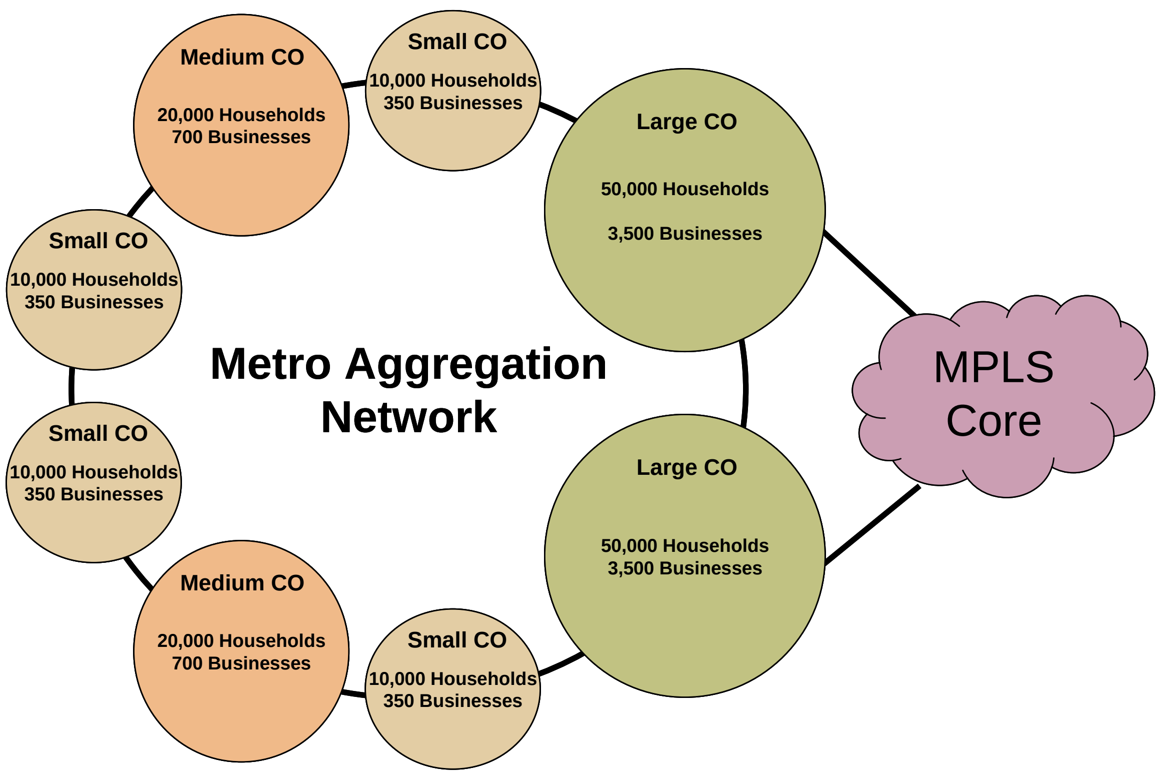
Metro Ethernet Optical Transport Architectural Alternatives

This section defines the Metro Ethernet Optical Transport network used to compute TCO and then describes both the logical and physical architectures for the ROADM and EtherBurst architectures.

Network Topology

A typical metro aggregation network is used to model the TCO of both the ROADM and EtherBurst architectures. Figure 3 shows the Metro Service Area topology.

Figure 3
Metro Service Area Topology

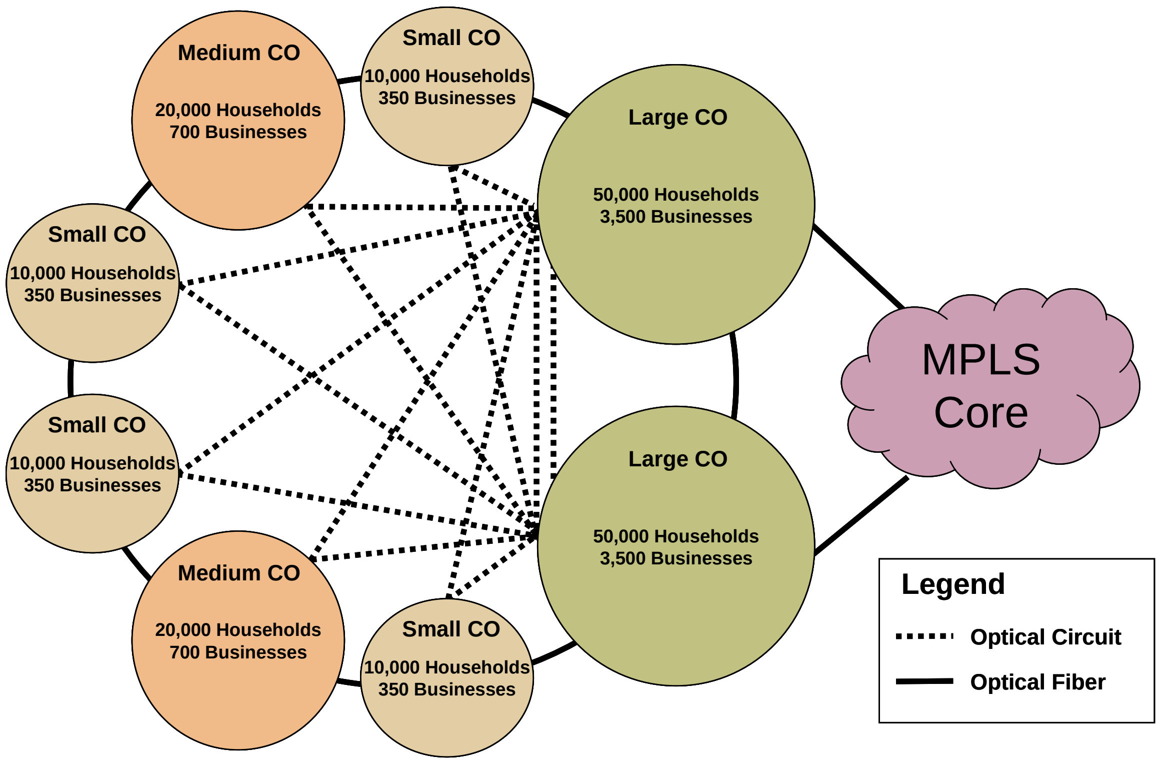


The model network consists of eight Central Offices—four small, two medium and two large Central Offices. The total number of households and business establishments are shown for each Central Office. For all three scenarios, a traffic model is used to project service quantities by applying penetration rates to the number of households and businesses in each Central Office. Both the ROADM and EtherBurst architectures use a physical ring topology where each Central Office sits on the metro fiber optic ring. The EtherBurst and ROADM architectures each use a different logical network topology, however, as detailed below. Each large Central Office also houses an aggregation router that handles the flow of traffic between the MPLS Core Network and the metro aggregation network.

ROADM Architecture

Figure 4 shows the ROADM logical network architecture.

Figure 4
ROADM Logical Network Architecture



The ROADM logical network architecture is a dual tree. Each Central Office is connected to an aggregation router located within each of the two large Central Offices. If more than 10 Gbps of bandwidth is required for the connection then additional 10 Gbps wavelengths (Optical Circuits) are assigned to each connection until the bandwidth requirement is satisfied. Layer 2 connections among Central Offices and to the Core Network are made by the aggregation router in each large Central Office. Notably, this includes Carrier Ethernet service connections among the Central Offices sitting on the metro aggregation network—On-Net connections[1].

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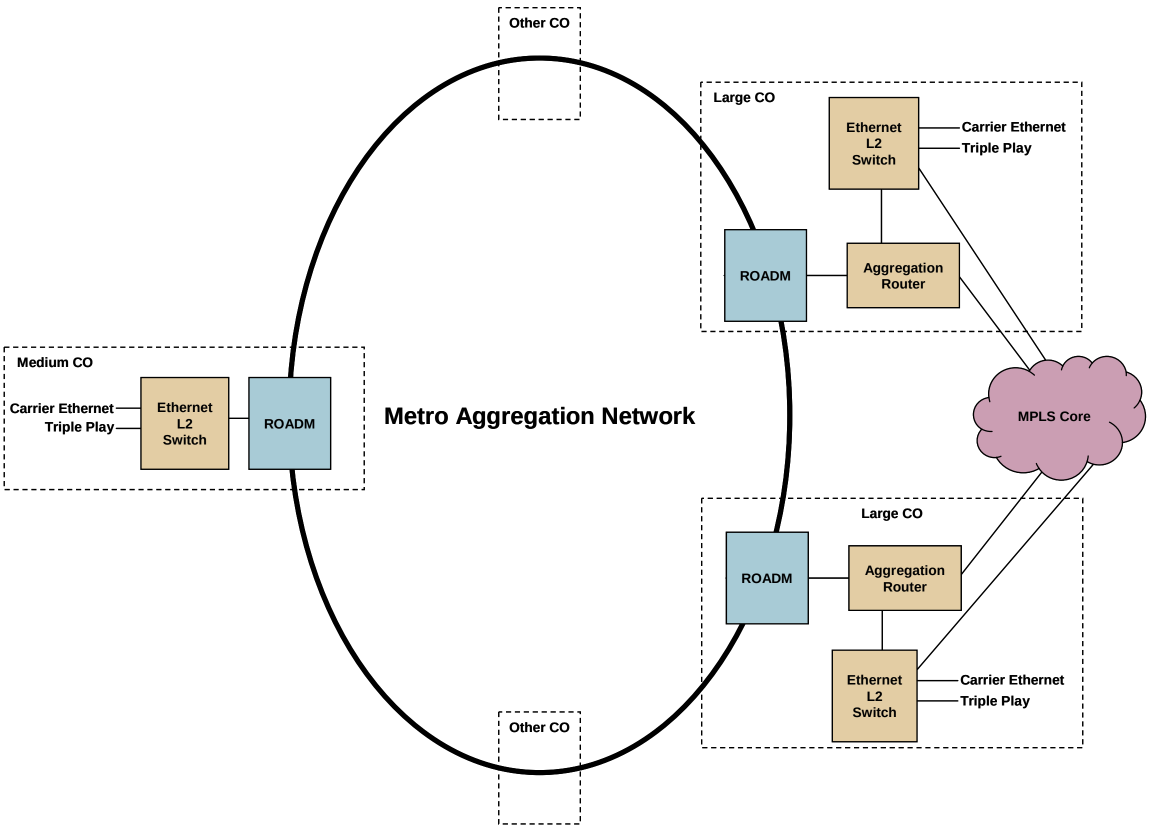
[1] On-Net connections (or traffic) are connections between Central Offices within the Aggregation Network. Off-Net connections are those that connect a Central Office within the Aggregation Network to the MPLS Core.

Figure 5 shows the ROADM physical architecture.

Figure 5
ROADM Physical Architecture



Each Central Office is connected by a ROADM onto a fiber-optic ring. The ROADM provides optical transport via 10 Gbps transponders to implement the logical architecture shown in Figure 4. When an optical circuit exceeds 10 Gbps additional transponders are used to meet the bandwidth requirement. The ROADM provides optical transport only and is connected to an aggregation router[2] that aggregates traffic for delivery to the MPLS Core network and performs layer 2 switching to provide connections among the Central Offices within the Metro Aggregation Network for Carrier Ethernet services (On-Net service). This division of transport and layer 2 switching functions requires Optical-Electrical-Optical (O-E-O) conversions and uses more DWDM transponders and more aggregation router ports than an architecture that does not require O-E-O conversions—such as EtherBurst to be discussed next. The cost associated with the extra transponders and router ports is referred to as the O-E-O Transit Tax.

This ROADM architecture is widely used by service providers today and as such is used in this TCO analysis as the base case against which the EtherBurst architecture is compared. The TCO calculations presented in this paper use equipment configurations

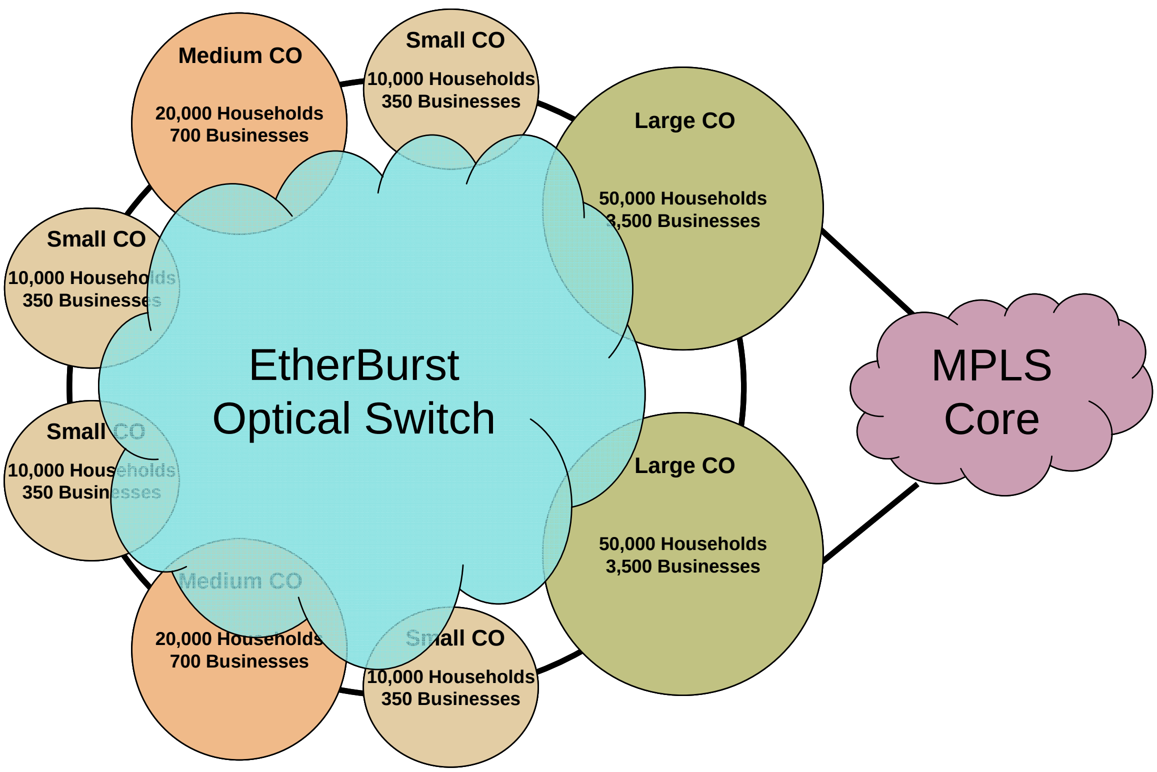
[2] Although referred to as an aggregation router this is an Ethernet Switch/Router that provides both layer 2 and layer 3 functions.

and pricing levels for market leading ROADM and Ethernet Switch/Router products. The Ethernet Switch/Routers are configured with layer 2 switch cards for the connections to the Metro Aggregation network and much higher priced MPLS-capable cards for connection to the MPLS Core network. Thus, the Metro Aggregation network has layer 2 functionality only. Should MPLS functionality be extended to the aggregation network then the negative effects of the O-E-O Transit Tax would be much larger due to the higher cost of MPLS line cards.

EtherBurst Architecture

Figure 6 shows the EtherBurst optical switch logical network architecture.

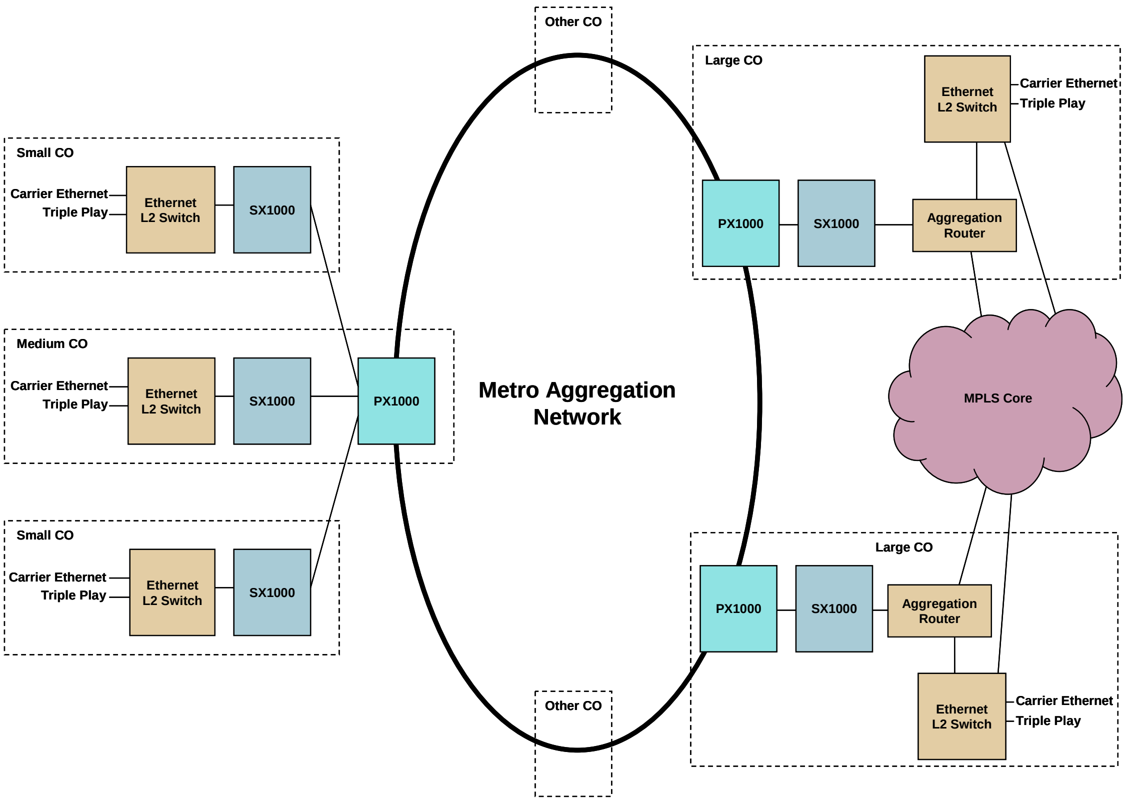
Figure 6
EtherBurst Logical Network Architecture



The EtherBurst logical network architecture is a full mesh, with all optical (O-O-O) any-to-any connectivity between nodes on the network. Full-mesh connectivity is enabled by optical burst switching technology, which assembles groups of Ethernet packets headed to various destinations on the ring and bursts them onto the color of light assigned as the destination nodes' address. The physical fiber-optic ring, therefore, acts in many ways as an Ethernet 'cloud'. As such some of the packet switching formerly performed by the aggregation switch/router is now provided by the EtherBurst optical switch. Unlike traditional Ethernet, the EtherBurst optical switch allows any-to-any connectivity with deterministic, fine-grain QoS for Ethernet services.

Figure 7 shows the EtherBurst physical architecture.

Figure 7
EtherBurst Physical Architecture



Ethernet Layer 2 Switches are used at every Central Office to terminate Carrier Ethernet and Triple Play services and to aggregate their traffic onto the Matisse Network's SX-1000 Ethernet Services Node. The SX-1000 provides the intelligence to map Ethernet packets onto the optical burst photonic network. It performs three critical functions:

- Ethernet packets are mapped onto different colored bursts of light to transmit packets to different destinations.
- Collision avoidance intelligence is used to ensure that no two transmitters send the same light wavelength at the same time.
- Metro-wide QoS is supplied to support shared intelligence of traffic loads, packet priorities and service level agreements across the entire metro aggregation network.

As shown in the figure, one or more SX-1000s are connected to a PX-1000 Photonic Node. Each SX-1000 supports up to two 10 Gbps optical burst switching transponders. Each optical burst transponder makes it possible to send and receive 10 Gbps bursts of data as different wavelengths of light. It can tune across the entire ITU C-band and lock onto new wavelengths in nanoseconds.

An additional Ethernet Switch/Router is located in each of the two large Central Offices and functions as an aggregation router. It routes traffic between the metro aggregation ring and the core network as well as provides connections between the Ethernet layer 2 Switch used to terminate Carrier Ethernet services that are local to the Large Central Office. Due to the very large size of each of the large Central Offices the Ethernet layer 2 Switches also are used to terminate locally generated traffic onto the network core.

The Ethernet layer 2 Switches and the aggregation routers are deployed in the same way as for the ROADM architecture—layer 2 switching is used exclusively on the aggregation network and MPLS is used in the core network. The TCO analyses uses the same market leading switching products for the EtherBurst architecture as are used for the ROADM architecture.

Carrier Ethernet Services Scenario

Total Cost of Ownership for the ROADM and EtherBurst architectures are compared by computing the cost to support three demand scenarios as defined in the Introduction. The first scenario examines the TCO benefits for a metro aggregation network used to support only Carrier Ethernet services.

Carrier Ethernet services reduce service providers' service delivery costs while supporting new offerings that embody higher-value (more profitable) service attributes.

Carrier Ethernet's capabilities are built upon the Metro Ethernet Forum's Ethernet Line (E-Line) and Ethernet LAN (E-LAN) service types. They are defined as:[3]

- E-Line – An Ethernet service type that is based on a Point-to-Point Ethernet Virtual Connection. Two E-Line services are defined:
  - EPL (Ethernet Private Line) – This is a very simple point-to-point service characterized by low Frame Delay, Frame Delay Variation and Frame Loss Ratio. No service multiplexing is allowed and other than a Committed Information Rate (CIR). No CoS (bandwidth profiling) is allowed.
  - EVPL (Ethernet Virtual Private Line) – This is a point-to-point service wherein service multiplexing (more than one Ethernet virtual circuit) is allowed. The individual Ethernet virtual circuits can be defined with the rich set of bandwidth profile and layer 2 control protocol processing methods defined by the Metro Ethernet Forum.

- E-LAN – An Ethernet service type that is based on a Multipoint-to-Multipoint Ethernet Virtual Connection. Service multiplexing—more than one Ethernet

[3] See MEF 6 – Ethernet Service Definitions – Phase I, Metro Ethernet Forum, June 2004 for the technical specification of E-Line and E-LAN service types.

Virtual Circuit at the same UNI—is permitted, as is the rich set of performance assurances defined by the MEF such as CIR with an associated Committed Burst Size (CBS) and Excess Information Rate (EIR).

Within the metro aggregation network these services are delivered using layer 2 switching alone, and MPLS is used to communicate with the core.[4]

Carrier Ethernet Traffic Projections

The hypothetical network used by the TCO model is derived from demographic data and current market research reports.[5] Traffic for the Metro Aggregation Network shown in Figure 3 is projected for each year of a five-year study period. Separate demand models are used for the small, medium and large Central Offices to reflect the varied demographic mix across a typical metro area. The large office is typical of what would be found in the city at the center of a metro area, while the medium office is typical for the first ring of suburbs and the small office would be found at the periphery of the metro area.

The traffic projection begins by estimating service penetration rates for each type of Central Office and for each Carrier Ethernet service. For example, Table 1 shows the penetration rates assumed for the large Central Offices.

Table 1
Carrier Ethernet Service Penetration Rates for Large Central Office

Service	Penetration Rates				
	Year 1	Year 2	Year 3	Year 4	Year 5
E-Line (EPL)	3.5%	5.4%	6.0%	6.0%	5.0%
E-LINE (EVPL)	2.7%	6.4%	11.4%	16.0%	21.5%
E-LAN	3.8%	8.2%	12.6%	18.0%	23.5%
Total	**10.0%**	**20.0%**	**30.0%**	**40.0%**	**50.0%**

EPL services have been available for some time. They are used for Internet access services or when offered at Gigabit speed as a means of connecting a data center used for web hosting to a Tier 1 Internet peering point—CIR is generally set at the port speed. EVPL service also is point-to-point or point-to-multipoint; however, service multiplexing allows the total bandwidth to be subdivided into several virtual circuits. This creates multiple opportunities to offer differentiated services over the same physical connection. For example, separate virtual circuits can be created to support Internet access, an enterprise private data network and video conferencing services. The projection calls for much faster development of EVPL service as it supplants the early EPL offerings. E-LAN service also has been available as Transparent LAN Service (TLS) for a long time.

[4] Connections among metro areas typically are made using an MPLS core and can be made at layer 2 as VPLS or at layer 3 as MPLS VPN service.
[5] See *State and Metropolitan Area Data Book: 2006*, U.S. Census Bureau as well as published reports of Heavy Reading, Network World and Vertical Systems Group

However, the modern service should grow rapidly now that carrier-class Ethernet is being realized and national and international connectivity can be supported through next-generation L2/L3 core networks. E-LAN services feature any-to-any connectivity and are offered with a rich variety of QoS alternatives. E-LAN is conceptually much like Frame Relay. It, however, is scalable into the Gigabit range while Frame Relay is limited to one or two Megabit speeds. This potential is reflected in the projection of rapid service penetration.

The traffic projection then is completed by forecasting the port type and data rate for each service and for each size Central Office. Table 2 shows the distribution of Carrier Ethernet customer ports by type and speed as well as the total bandwidth flowing into or out of the Large Central Office.

Table 2
Carrier Ethernet by Port Type and Speed for Large Central Office

			Bandwidth in/out Large Central Office (Gbps)				
Service	Port Speed (Mbps)	CIR (Mbps)	Year 1	Year 2	Year 3	Year 4	Year 5
E-Line (EPL)	10	10	0.8	1.3	1.6	1.6	1.4
	100	100	3.3	4.4	4.1	3.5	2.5
	1,000	1,000	8.0	13.0	15.0	16.0	15.0
E-LINE (EVPL)	10	3	0.2	0.5	0.9	1.3	1.8
	100	30	0.8	1.6	2.3	2.8	3.2
	1,000	300	1.8	4.5	8.1	12.3	18.3
E-LAN	10	3	0.3	0.6	1.0	1.4	1.9
	100	30	1.1	2.0	2.6	3.1	3.5
	1,000	300	2.4	5.7	9.0	13.8	20.1
Total Bandwidth in/out Large Central Office			**18.7**	**33.6**	**44.5**	**55.8**	**67.7**

The table shows that a large Central Office will require tens of Gigabits of bandwidth capacity to accommodate expected service penetration rates and data rates for Carrier Ethernet services. E-LAN services with their any-to-any traffic patterns become the largest bandwidth contributors even though individual customer port CIR is about one-third that of EPL services.

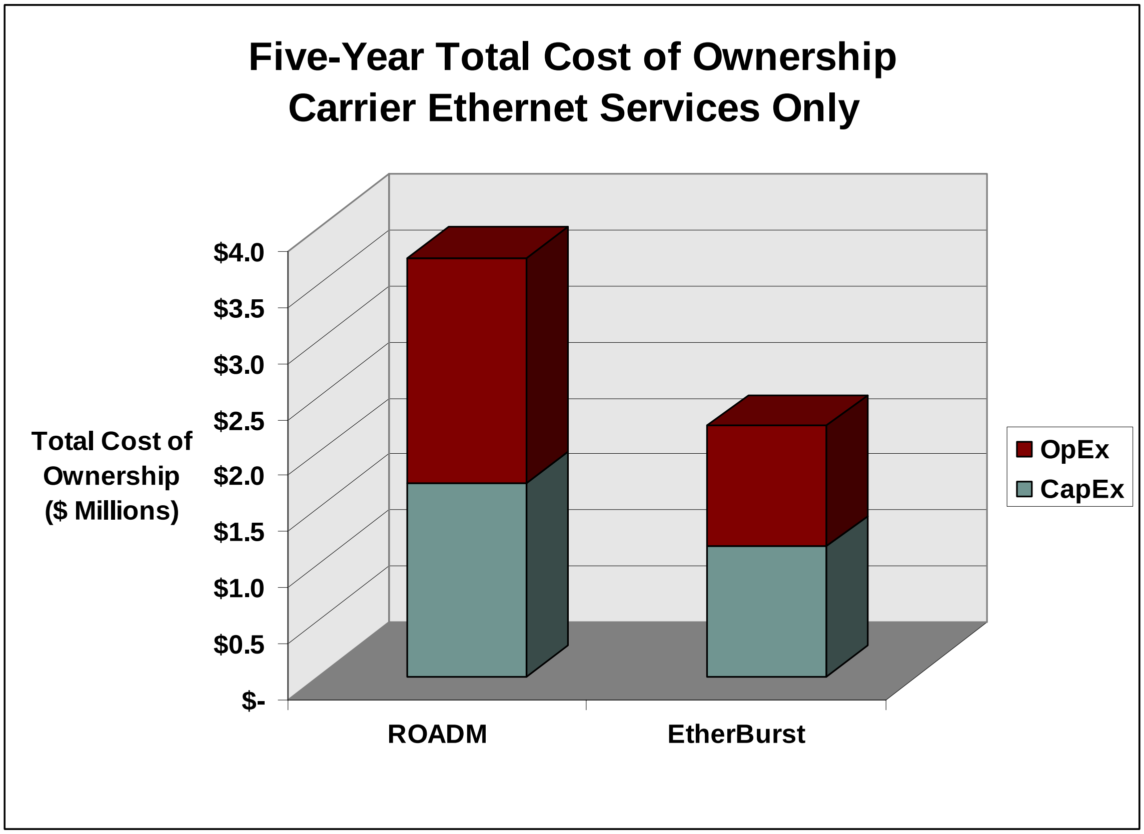
Similar tables are created for the medium and small Central Offices and then used to project traffic demand for all eight Central Offices, the traffic on the aggregation ring and the traffic between the Metro Aggregation network and the MPLS Core network.

TCO for each architecture is then calculated using this traffic projection.

Total Cost of Ownership Analysis for Carrier Ethernet Services Optical Transport

This section analyses the total cost of ownership (TCO) for the optical systems elements of the metro aggregation network (the optical systems elements are the EtherBurst SX-1000 and PX-1000 chassis and the ROADMs.) Figure 8 summarizes the five-year TCO for each architecture as implemented to meet the traffic requirements and network topology defined previously.

Figure 8
Five-Year Total Cost of Ownership for Carrier Ethernet Services



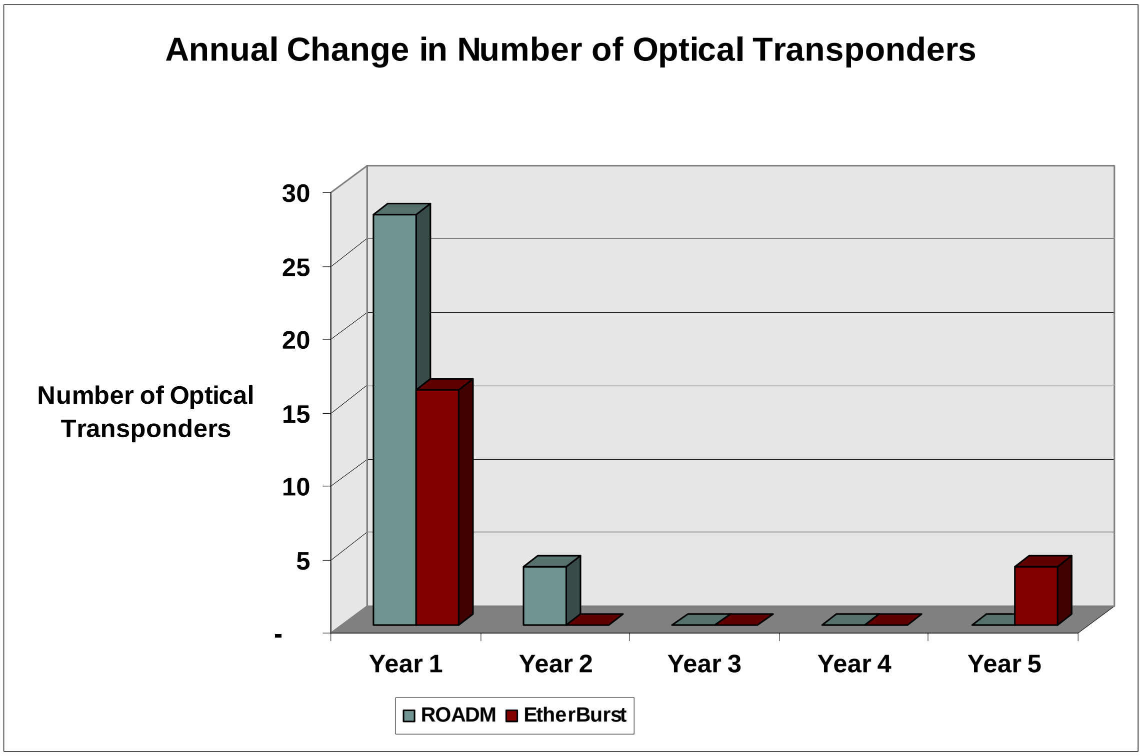
The figure shows a large five-year TCO savings for EtherBurst as compared to the ROADM architecture. EtherBurst has 40% lower TCO than ROADM. EtherBurst has 33% lower CapEx and 46% lower OpEx than ROADM.

Sources of CapEx Savings

The EtherBurst architecture produces this CapEx savings compared to the ROADM architecture through its all optical switching design that eliminates expensive optical-electrical-optical (OEO) interconnections and its any packet to any wavelength flexibility that results in increased transmission channel efficiency. It achieves further improved asset utilization by sharing optical transponder capacity across all nodes on the metro access ring as compared to the ROADM architecture's requirement that at least one transponder be dedicated to each optical path between each node and each aggregation router.

Figure 9 shows the primary source of these EtherBurst architectural cost savings—the reduction in the number of transponders required with the EtherBurst solution.

Figure 9
Annual Change in Number of Optical Transponders

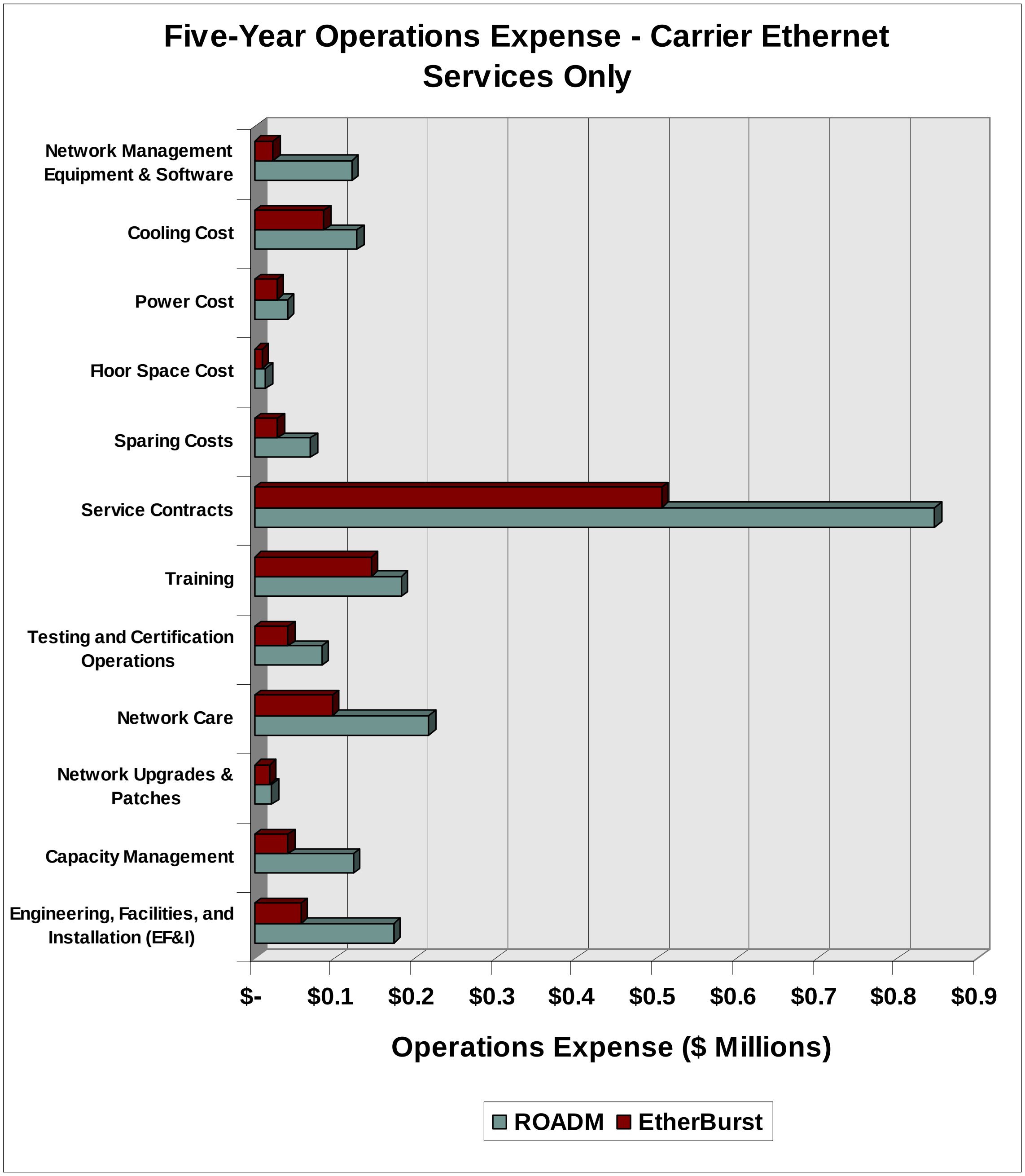


The ROADM architecture requires nearly twice as many transponders in the first study year and the addition of four additional transponders in the second year. EtherBurst's more efficient use of channel capacity not only results in much lower first year transponder requirements but does not require supplemental capacity additions until the fifth year of the study.

Sources of OpEx Savings

EtherBurst operations expenses are 46% less than those of the ROADM architecture. This is an even greater savings than for CapEx. Figure 10 drills down into the sources of these savings.

Figure 10
Five-Year Operations Expenses for Carrier Ethernet Services Only



Service Contract costs are the largest single source of OpEx savings. This is so because service contract charges are tied to original equipment costs and EtherBurst has 33% lower equipment costs. EF&I, Network Care, Network Management Equipment and Software, and Capacity Management expenses also are important sources of OpEx savings. Elements of the EtherBurst architecture that produce these OpEx savings include:

- Ease of installation – EtherBurst is a plug and play operation. Planning and provisioning of optical circuits is eliminated.

- Ease of maintenance – EtherBurst's integrated packet and optical trouble shooting feature simplifies maintenance as compared to the ROADM/Ethernet Switch-Router combination that requires discrete trouble shooting of each system.

- Ease of re-allocating optical capacity – EtherBurst enables automatic control and re-allocation of optical capacity based on QoS information in standard Ethernet frame formats.

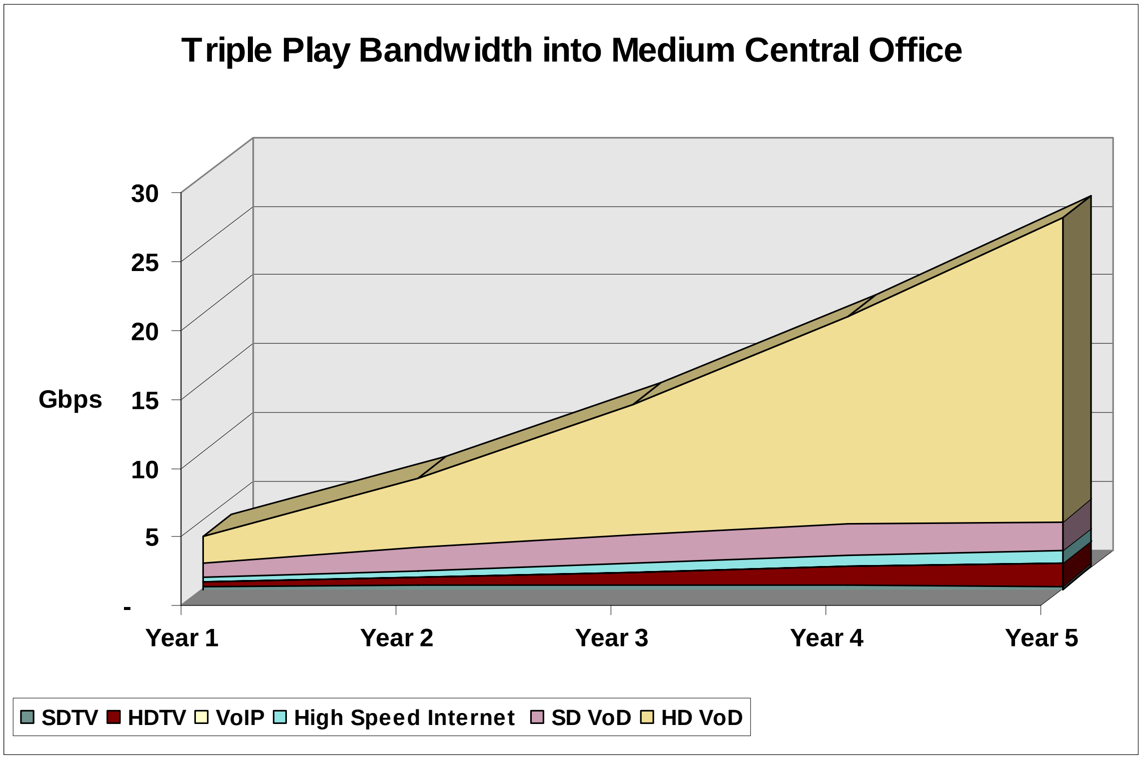
Efficient Handling of On-Net Traffic

The EtherBurst architecture also produces CapEx savings through its any-to-any connectivity. Carrier Ethernet traffic between any Central Office pair within the aggregation network—On-Net traffic—is switched directly across the fiber-optic path between the Central Office pair. In contrast, the ROADM architecture always transports traffic to the aggregation router. The aggregation router performs the Ethernet switching function and then the packets are transported back to the second Central Office. Consequently, the ROADM architecture requires more CapEx for optical transport and aggregation switching than does the EtherBurst architecture.

TCO Analysis for Triple Play Services

The same metro aggregation network used to analyze the TCO for Carrier Ethernet traffic is used to analyze the TCO for a network dedicated to Triple Play services. Traffic forecasts are created for each size Central Office and then used to project traffic for each of the eight Central Offices, the aggregation network as a whole and the flows to the MPLS Core network. For example, Figure 11 shows the traffic forecast for bandwidth going into a medium sized Central Office.

Figure 11
Triple Play Bandwidth into Medium Central Office



The figure shows that the Triple Play bandwidth sources are Standard Definition broadcast Television, High Definition broadcast Television, VoIP, High Speed Internet access service, Standard Definition Video on Demand and High Definition Video on Demand. The projections are based upon market research projections of expected consumer demand for a metro area in a first tier market[6].

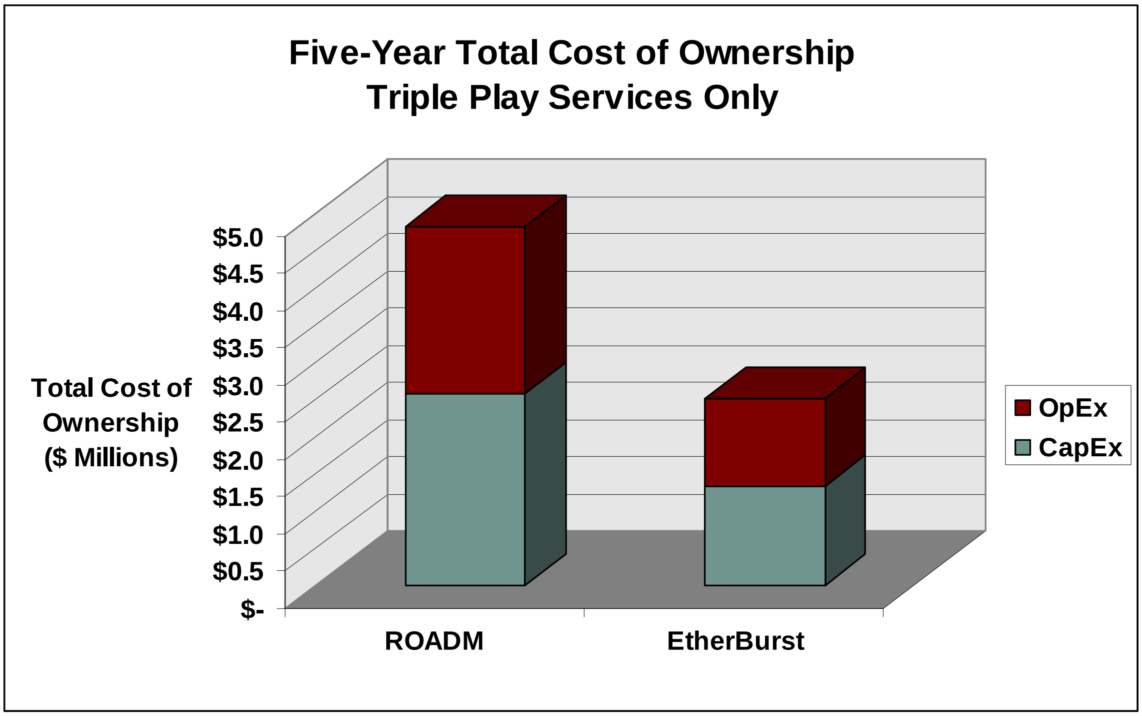
Two trends dominate the bandwidth forecast. First, a rapid changeover from standard definition to high definition television is expected over the next five years. Second, high take up rates for Video on Demand (VoD) services are projected. The move to high definition television is an accomplished fact. New shipments of high definition television

[6] See "A Business Case Comparison of Carrier Ethernet Designs for Triple Play Networks", Network Strategy Partners, March 2007, http://www.nspllc.com/NewPages/SFHVPLS.pdf for a detailed description of the traffic requirements and projections for Triple Play services.

sets are outpacing standard definition sets in developed markets today. Second, VoD is essential to both incumbent and new entrant Triple Play strategies. VoD can provide a service differentiator to the operator with the most highly capable access network and can be used by a new provider to gain market entry and by an incumbent to both limit new entrants and to improve average revenue per user (ARPU).

Figure 12 provides a TCO comparison of EtherBurst versus ROADM for the metro aggregation network used exclusively for Triple Play services.

Figure 12
TCO for Optical Systems for Triple Play Metro Aggregation Network



The figure shows that the EtherBurst TCO savings for a network used to provide Triple Play services is about half the TCO for the ROADM architecture. EtherBurst five-year TCO is 48% less than ROADM. EtherBurst has 48% lower CapEx and 47% lower OpEx than ROADM. EtherBurst's integration of Ethernet packet processing and optical transport produces several cost savings for the delivery of Triple Play services.

- Broadcast television is efficiently delivered as IP multicast traffic on the optical ring. This contrasts with the ROADM architecture where every point-to-point optical path from each Central Office to each of the access routers must carry its own copy of the multicast traffic.

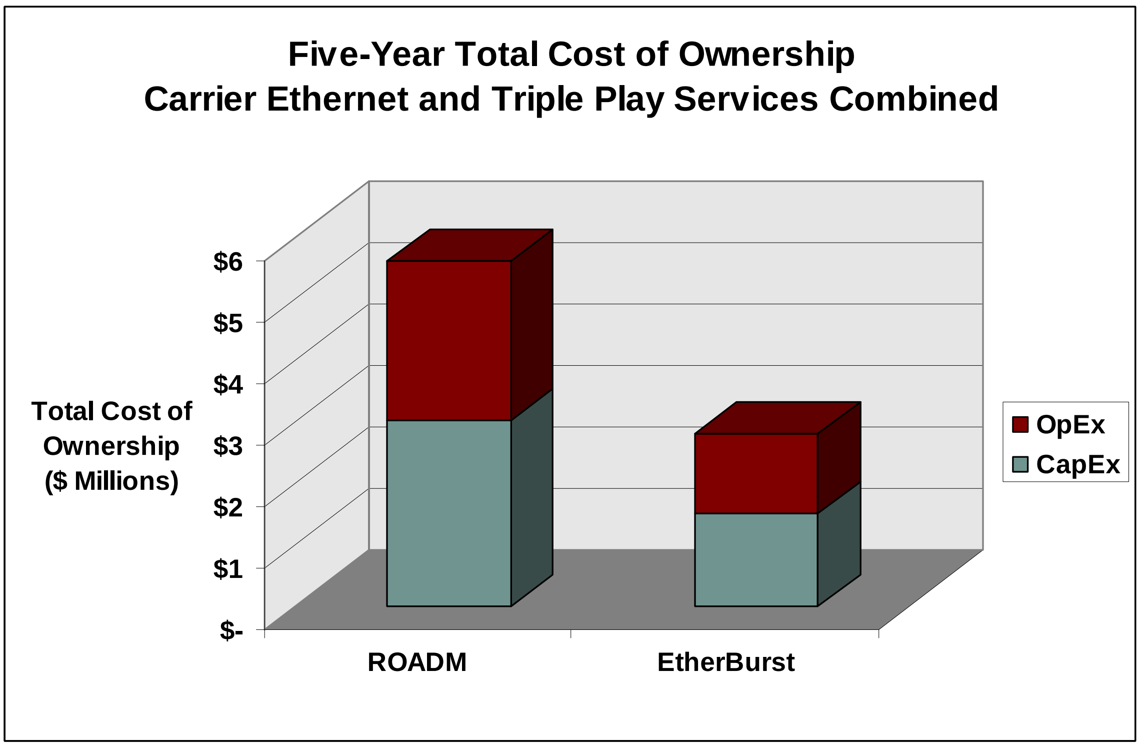
- IPTV traffic whether multicast or unicast for VoD service can be delivered with premium QoS. This provides operators with the ability to compete on the basis of quality of experience.

- EtherBurst provides bandwidth flexibility for efficient delivery of VoD traffic where and when needed. This eliminates stranded bandwidth—bandwidth that is “nailed-up” between each Central Office and the Aggregation Router.

TCO Analysis for Converged Carrier Ethernet and Triple Play Network

Carrier Ethernet services are broadly attractive to enterprise establishments of all sizes and can be found even in predominantly residential areas. Most Central Offices, therefore, will serve both residential and commercial customers. The metro aggregation network consequently must deliver both Carrier Ethernet and Triple Play services. Figure 13 provides a five-year TCO comparison for such a converged network.

Figure 13
Five-Year TCO for Optical Systems for Metro Aggregation Network with Carrier Ethernet and Triple Play Traffic



The TCO for EtherBurst as compared to ROADM is even more favorable with Carrier Ethernet and Triple Play services combined. EtherBurst five-year TCO is 50% less than ROADM. EtherBurst has 50% lower CapEx and 51% lower OpEx than ROADM. This is due to the superior scaling of the EtherBurst architecture as traffic bandwidth exceeds 10 Gbps. As bandwidth demand scales to 10Gbps and beyond, the relative savings of EtherBurst continues to increase when compared against ROADM systems for metro Ethernet optical transport networks. CapEx savings are primarily due to optical burst switching's more efficient utilization of optical transport capacity for packet services. With EtherBurst, relative utilization is further increased by finer-grain QoS and more efficient handling of multicast traffic. OpEx reduction is due to the relative ease of provisioning, managing and maintaining packet optical transport with EtherBurst, which results from the elimination of planning, provisioning and reconfiguring optical circuits.

Additional Factors Favoring the EtherBurst Architecture

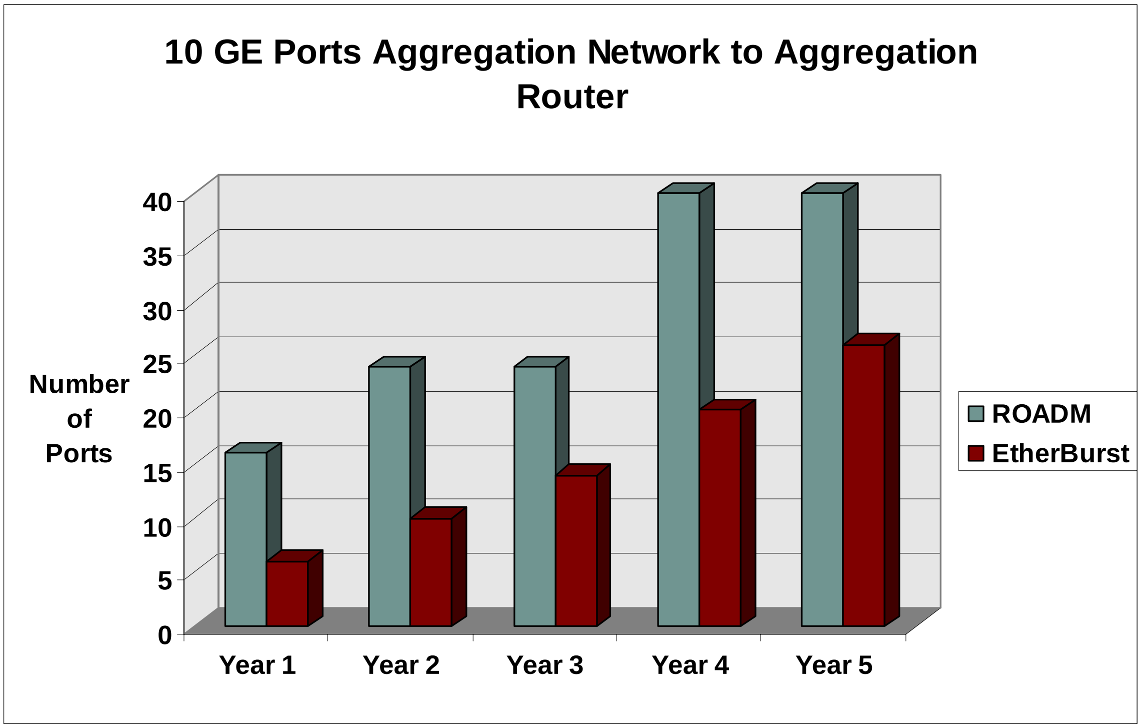
The previous TCO analysis presented results for only the optical transport network systems themselves—the EtherBurst systems and the ROADM. EtherBurst, through its more efficient use of transport channels, also reduces the cost of the aggregation routers that connect the metro aggregation network to the core network. EtherBurst also facilitates service innovation.

Reduction in Aggregation Router TCO

The EtherBurst architecture integrates Ethernet packet processing with optical transport. The number of Ethernet ports required to connect to each aggregation router, consequently, is determined by the total I/O bandwidth requirement. In contrast, the ROADM architecture requires that each point-to-point optical path from the aggregation router to each Central Office be terminated by at least one port on the aggregation router. This hinders efficient bandwidth utilization.

Figure 14 illustrates this effect for the combined services model analyzed in the last section.

Figure 14
Number of Ethernet Ports Required to Connect Aggregation Router to the Metro Aggregation Network



The figure shows that in the initial year when total traffic is lowest that EtherBurst has a 3:1 aggregation router port utilization advantage over the ROADM architecture. In later years with high traffic growth the EtherBurst port utilization advantage narrows but none-the-less remains significant.

Advantages of Integrated Ethernet and Optical Systems

EtherBurst's integration of the Ethernet and optical functions and its use of standards-based carrier-class Ethernet provide additional economic advantages including strong support for any-to-any services and a wide range of service topologies.

Any-to-Any Services Support

Ethernet services characterized by any node to any other node traffic patterns are important to many service providers' strategies for profitable growth. Examples of such fast growing services include:

- E-LAN services – These services that were shown to be an important component of the Carrier Ethernet service portfolio are likely to supplant Frame Relay as the dominant medium and large enterprise data communications service offering.

- Sharing Multimedia Content – The popularity of MP3 music sharing, digital photography, and P2P protocols are rapidly democratizing video distribution. This creates any-to-any traffic patterns that are far different from those associated with downloading videos, pictures, and music from a handful of large media outlets.

- Local add insertion for IPTV offerings – IPTV offers the potential for much wider viewing choice and programming that appeals to very narrow market segments. It similarly enables advertisers to affordably reach very specific customer segments. The ability to easily insert local ads targeted to specific audiences is essential to implementing this business model.

EtherBurst's integration of Ethernet and optical transmission provides the responsive and low cost architecture to meet the needs of these important any-to-any services.

Conclusion

The Matisse Networks EtherBurst Optical Switch employs optical burst technology to overcome the limitations of metro aggregation network architectures that use DWDM ROADM systems to transport packet services. It provides scalable bandwidth across the metro aggregation network up to 640 Gbps. This provides many TCO advantages as compared to the ROADM architecture including:

- EtherBurst has 40% less TCO for the optical systems in a metro aggregation network dedicated to Carrier Ethernet services.

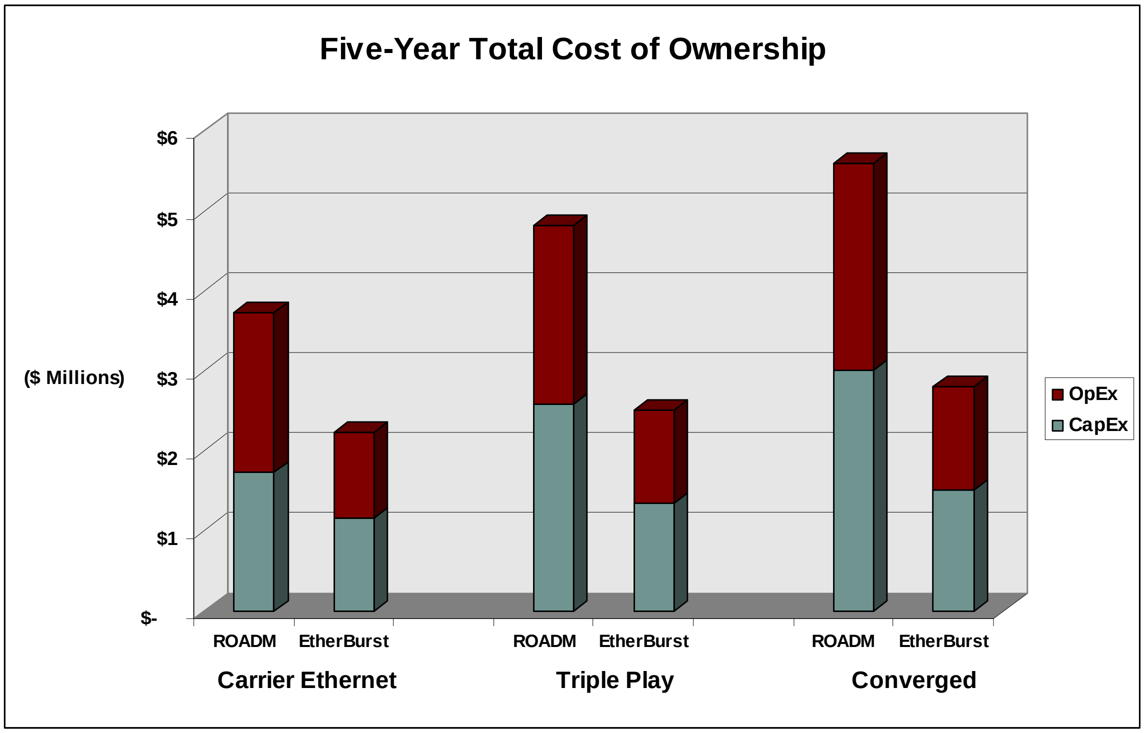
- EtherBurst has 48% less TCO for a metro aggregation network dedicated to Triple Play service delivery.

- EtherBurst has 50% TCO savings when delivering both Carrier Ethernet and Triple Play services together.

As bandwidth demand scales to 10Gbps and beyond, the relative savings of EtherBurst continues to increase when compared against ROADM systems for metro Ethernet optical transport networks. CapEx savings are primarily due to optical burst switching's more efficient utilization of optical transport capacity for packet services. With EtherBurst, relative utilization is further increased by finer-grain QoS and more efficient handling of multicast traffic. OpEx reduction is due to the relative ease of provisioning, managing and maintaining packet optical transport with EtherBurst, which results from the elimination of planning, provisioning and reconfiguring optical circuits.

Figure 15 summarizes the CapEx and OpEx results for the three scenarios.

Figure 15
Total Cost of Ownership Summary



In addition to these savings, the associated switch/router architecture is simplified, and fewer 10GE ports are required as a result of EtherBurst's integration of layer2 intelligence into the optical transport.