White Paper

Business Case for Carrier Ethernet Services

Executive Summary

Service providers are facing vital business issues as the industry moves from service portfolios based on circuit-switched voice and TDM/PDH-based transport to converged networks employing Ethernet, Multiprotocol Label Switching (MPLS), and IP. One problem is creating revenue growth while maintaining profit margins. This cannot be achieved merely by substituting higher-speed IP services for existing voice, T1/E1, and Frame Relay services. New enterprise service offerings based on Ethernet and MPLS provide capabilities to help resolve service providers' revenue and profit margin dilemmas.

Carrier Ethernet services built on the Ethernet Line (E-Line) and Ethernet LAN (E-LAN) service types defined by the Metro Ethernet Forum (MEF) provide the foundation for service revenue growth. They support a broad range of value-added services that can be sold at higher price points. When combined with MPLS technologies, Layer 3 MPLS VPN-based services support additional service offerings and help reduce total cost of ownership (TCO), directly addressing service providers' profitability concerns.

This paper describes the architectures and Cisco® products used to deploy a Carrier Ethernet/MPLS network on a national or international scale, and presents a case study that demonstrates the attractive cash flow that can be generated by such a project.

Introduction

Carrier Ethernet services and technology are essential to service providers' migration from traditional networks and their associated service offerings to a new service portfolio using converged network technology. Combined with MPLS, Carrier Ethernet provides the capability to simultaneously reduce service delivery cost and induce customers to move to more attractive (and more profitable) service offerings.

Carrier Ethernet flexibly accommodates several Layer 2 and Layer 3 approaches so that capital and operational expenses, performance, security, and resiliency can be tied closely to individual service provider offerings, network build-outs, and technology migration plans. Carrier Ethernet supports creation of highly differentiated access services by allowing specification of parameters such as delay, jitter, and packet loss. This permits creation of data, voice, and video service offerings using Carrier Ethernet transport where application quality of service (QoS) is defined to meet the exact application requirements – such as tight delay requirements for voice or high tolerance of delay variation for data. The ability to create highly differentiated access services also supports increased revenue and better operating margins by enabling service offerings to precisely balance individual customers' service preferences and their willingness to pay.

A series of metropolitan (metro) areas can be built out to support Carrier Ethernet services. They can then be linked by an MPLS network to form a national or global Carrier Ethernet service offering. Because MPLS supports a variety of Carrier Ethernet technical solutions, service providers can design each metro solution to meet individual business and technical requirements while providing a single Carrier Ethernet service suite at all network endpoints. Through capabilities such as mesh networking, traffic engineering, and fast reroute, MPLS provides the scalability, flexibility, and low cost points required of converged network solutions.

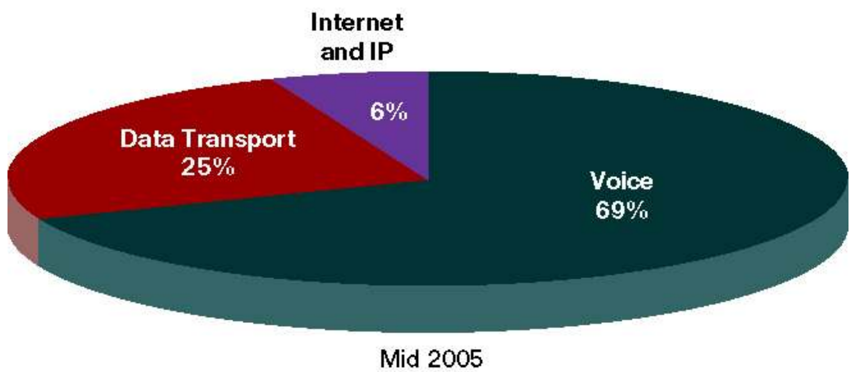
The broad Cisco portfolio of MEF-certified Ethernet products and its leading position in MPLS networking support all combinations of Carrier Ethernet/MPLS networking solutions. The benefits of using Cisco Carrier Ethernet and MPLS capabilities are illustrated in a case study that analyzes the cash flow produced by offering Carrier Ethernet services (E-Line and E-LAN) and MPLS VPN services across large and medium metro areas.

Strategic Role of Carrier Ethernet and MPLS

Wireline carriers are in the midst of a fundamental restructuring of their businesses necessitated by new technology, including IP networking, optical transmission, and fixed and mobile wireless, as well as the global movement toward industry liberalization and privatization. This white paper analyzes this process using U.S. wireline carrier revenue[1] as an example. Figure 1 shows the revenue mix as of midyear 2005.

Figure 1

U.S. Wireline Carrier Revenue as of Midyear 2005



Voice services continue to dominate service provider revenue in both the consumer and enterprise market segments. Though voice-over-IP (VoIP) services are rapidly emerging, this US$110 billion market continues to be dominated by circuit-switched voice technology. Nearly all consumer services continue to be provided over analog voice lines, while enterprise voice uses analog, T1, or T3 lines for access to local circuit switches. The data transport segment of Figure 1 consists primarily of traditional transport services such as T1 and Frame Relay. About 15 percent of this revenue is accounted for by private line services using optical transport mostly at the DS-3 (45 Mbps) and OC-3 (155 Mbps) data rates. The "Internet and IP" segment includes Internet, DSL, IP-VPN, and other IP services such as hosting. Most of this revenue consists of Internet backbone and DSL services. Also, while declining in number, dialup Internet access users continue to outnumber broadband users.[2] Dialup uses voice access lines and thus does not contribute much revenue to carriers because most usage is within the flat-rate local calling area.

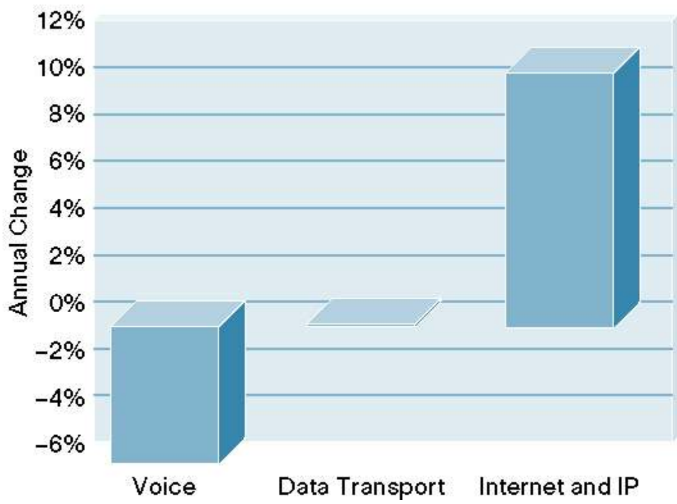
[1] Source is Q2 CY2005 SEC filings of AT&T, BellSouth, MCI, Qwest, SBC, Sprint, and Verizon that together represent more than 95 percent of U.S. wireline carrier revenue.

[2] Vertical Systems estimates that in 2005 60 percent of U.S. residential and 52 percent of U.S. business Internet access connections are dialup.

Figure 2 shows the year-to-year change in U.S. wireline carrier revenue.

Figure 2

Year-to-Year Change in U.S. Wireline Carrier Revenue as of Midyear 2005



Voice revenue dropped 6 percent over the last year while data transport revenue was unchanged and Internet and IP services revenue increased by 11 percent. Voice revenue is being lost to wireless providers and through price decreases that are the result of aggressive service bundling strategies. Although of great strategic concern, losses of voice revenue to cable MSOs and VoIP services are not yet materially significant. Data transport revenue in total held still, but this masks continued demand growth offset by price cuts and the substitution of IP for transport services. Internet and IP service revenue is the only increasing market segment. Most of this growth is due to increases in DSL service. Strong DSL revenue growth is not necessarily good, however, because end users are increasingly using their DSL lines to access VoIP services offered by third parties. This threatens the wireline carriers' large and highly profitable voice services business. In total, U.S. wireline carrier revenue dropped by 4 percent over the last 12 months.

Business Implications of Revenue Dislocations

The combined effect of the many shifts and dislocations in wireline carrier revenue are threatening the wireline carrier business case. Wireline voice revenue and even more of the operating profit face strong downward pressure from substitutes, including wireless, cable MSOs, and VoIP. Data transport service revenue is derived mostly from TDM/PDH offerings and Frame Relay. These services generally operate at or below 1.5/2 Mbps – and adds, moves, and changes are cumbersome. They are becoming obsolete and will give way to newer IP-based services. However, the data transport services were priced using cost-based formulas developed during the price-regulation era and consequently have much higher margins than their replacements. For example, small business DSL service with 3 Mbps down and 768 kbps up is offered in the United States at US$40 per month. This replaces the prior small business Internet access service offering that used a 256-kbps fractional T1 line and was priced at US$500 per month.

Wireline carriers cannot sustain their businesses by merely substituting higher speed IP-based services for their existing voice, T1/E1, and Frame Relay services.

Carrier Ethernet Services

Carrier Ethernet services provide capabilities to help resolve service providers' revenue and profit margin dilemmas. They do this by simultaneously reducing the cost to deliver existing services while supporting new offerings that embody higher-value (more profitable) service attributes.

Carrier Ethernet capabilities are built on the MEF E-Line and E-LAN service types:[3]

- E-Line – This Ethernet service type is based on a point-to-point Ethernet virtual connection. Two E-Line services are defined:
  - Ethernet Private Line (EPL) – 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 class of service (CoS) bandwidth profiling is allowed.
  - Ethernet Virtual Private Line (EVPL) – This is a point-to-point service in which 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 MEF.
- E-LAN – This Ethernet service type is based on a multipoint-to-multipoint Ethernet virtual connection. Service multiplexing – more than one Ethernet virtual circuit at the same User-Network Interface (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).

These MEF service definitions (and their associated technical implementations) are key to helping service providers profitably migrate their customers from existing TDM/PDH and Frame Relay services to next-generation services delivered over a much higher-speed converged network infrastructure. The MEF definitions maintain and extend desirable characteristics of these older services, including:

- Performance guarantees – The MEF CoS mechanisms and Layer 2 control processing methods provide guaranteed performance of such parameters as delay variation, information rates, and information loss recovery mechanisms.
- Security – Layer 2 networks that employ virtual circuits such as Frame Relay and point-to-point private lines such as T1/E1 are considered to be highly secure. The MEF E-LAN and E-Line services are equally secure.

The E-Line and E-LAN performance assurance mechanisms such as CIR and EIR support a much wider range of price-differentiated service offerings than older service offerings did. For example, Frame Relay PVCs permit a limited range of price-versus-data speed choices, but the data rates typically top out at 1.5 Mbps, and the variable component of the service price is limited by the high fixed-cost port charge. E-LAN services in contrast are offered with CIRs ranging from 1 Mbps to 1 Gbps, but fixed costs are roughly the same as for the much slower T1 service ports. The ability to offer a much wider range of price and service choices ensures that the service provider receives enough revenue from high-end users to make lower speed services affordable to the customer. This can increase revenue by as much as three times those of fixed-price service offerings. This increase is accomplished by providing a large number of price and performance choices so that the step up to each higher price tier is small, helping precisely match willingness to spend with supply. Consider the large price and performance gap between T1 (1.5 Mbps) and DS-3 (45 Mbps) private line services. Few customers have the need for 45-Mbps service or the willingness to pay its high monthly recurring charge. A much larger market, however, exists for 20-Mbps service. Service providers cannot effectively address this market using DS-3 technology because their costs for offering 20- and 45-Mbps service are the same. Carrier Ethernet service, however, supports many different data rates between 1.5 and 45 Mbps on a smoothly increasing and affordable cost curve.

[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.

Carrier Ethernet also delivers lower TCO than traditional infrastructure. The basis of the cost advantage is the creation of a converged network, yielding:

- Reduced network complexity due to fewer network elements and simpler network operations[4]
- Higher-capacity network elements and consequently greater economies of scale
- Simpler network provisioning and configuration management with lower cost and faster service provisioning, which eliminate many moves or changes[5]
- Lower capital expenditures (CapEx) than TDM/SONET (PDH/SDH) because Ethernet technology is more widely deployed and built on a less-complex specification
- Links to ubiquitous and very low cost Ethernet equipment at customer sites

Cisco MEF-Certified Products

The MEF certification program is intended to accelerate the adoption of Carrier Ethernet by helping service providers evaluate the equipment of various vendors and making it easier to provide the primary features of Carrier Ethernet: rapid service creation, smooth scalability to 10 Gbps, end-to-end protection, robust service-level agreements, and flexible support for voice, Internet, and multicast traffic.

The MEF announced its first certification testing results in September 2005. Cisco Systems® has the largest number of certified products by a wide margin – 10 of 39 certified products:

- Cisco Catalyst® 3750 Metro Series Switch
- Cisco Catalyst 4500 Series Switch
- Cisco Catalyst 4948-10G
- Cisco Catalyst 6500 Series Supervisor Engine 720
- Cisco Catalyst 6500 Supervisor Engine 32
- Cisco 7600 Series Router Supervisor Engine 720
- Cisco ONS 15454 ML-Series
- Cisco ONS 15454 CE-Series
- Cisco ONS 15310 ML-Series
- Cisco ONS 15310 CE-Series

MPLS VPN Services

MPLS VPN (RFC 2547) services also provide capabilities that help resolve service providers' strategic dilemma. In particular, they provide a migration path from existing transport service offerings (especially Frame Relay) to a managed IP (Layer 3) offering that supports expanded revenue without profit margin erosion – margin erosion has been particularly problematic for many IP service offerings.

MPLS VPN service uses a service provider's IP backbone to deliver managed Layer 3 VPN services. MPLS is used for forwarding packets, and Border Gateway Protocol (BGP) is used for distributing routes over the backbone. IP backbone service management is outsourced to the service

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[4] See "Metro Ethernet Networks – Comparison to Legacy SONET/SDH MANs for Metro Data Service Providers," July 2003, Metro Ethernet Forum, http://www.metroethernetforum.org/WP_SPBusinessCase_Final071403.pdf.

[5] See "Service Provider Business Case Study: Operating Expenditures," January 2004, Metro Ethernet Forum, http://www.metroethernetforum.org/PDFs/WhitePapers/Provider-Business-Case-OpEx-Study-Summary.pdf.

provider, and delivery costs are kept low through scalable and flexible service delivery mechanisms. This scenario produces a strong source of revenue growth with above-average margins.

Service providers are positioning MPLS VPN service as an upgrade option to their existing Frame Relay customers, emphasizing the following benefits:

- Managed IP services – Such services simplify and reduce a customer's internal costs of managing its own IP services. This setup is especially attractive for extranets where individual participants' network ownership could be problematic.
- Support for several QoS levels – This is an attractive up-sell opportunity because many enterprises are just beginning to assess the requirements for adding voice and video to their IP networks. MPLS VPNs also provide better QoS support than many customer-operated VPNs that employ customer premise equipment (CPE), Secure Sockets Layer (SSL), and software for VPN functions.
- Secure, easily managed connectivity – Virtual routing and forwarding (VRF) creates a secure Layer 3 VPN. Unlike ATM and Frame Relay solutions, virtual circuits do not need to be defined for connectivity to each networked location.

Case Study

In this case study a hypothetical network using Cisco equipment is built out to support a suite of new services. It is studied over a five-year period and a business model is used to calculate revenue, capital, operating expenses, and associated discounted cash flows based on a set of assumptions for geography, services, and architecture.

Geographic Assumptions

The case study examines a set of metro areas that are interconnected by an international MPLS backbone network. In this scenario, services are provided both within the metro area and between metro areas across the international backbone. Two types of metro areas are considered in the model. Their geographical characteristics are presented in Table 1.

Table 1. Geographical Characteristics of the Case Study Scenario

Type of Metro Area	Number of Business Establishments	Quantity in Case Study
Large	100,000	4
Medium	40,000	20

Large metro areas are major business centers such as London, Paris, or New York. Medium metro areas are the second tier below the major business centers. Business establishments are sites with 20 or more employees. They include those of single-site businesses as well as establishments of large enterprises ranging from small branch offices to corporate headquarters and major data centers. The sizing of the metro areas is consistent with MEF models.

Service Assumptions[6]

Three services are considered in this case study:

- E-Line (Layer 2 Carrier Ethernet service)
- E-LAN (Layer 2 Carrier Ethernet service)
- MPLS VPN (Layer 3 IP VPN service)

[6] The service projections are made by Network Strategy Partners (www.nspllc.com) based on its work for service providers and enterprises and market projections published by Vertical Systems Group (www.verticalsystems.com).

These services are used to provide a combination of:

- Wholesale services
- Internet access services
- Private corporate network services

These services are further specified in terms of port speed as well as mean CIR. Table 2 shows monthly pricing as a function of these parameters.

Table 2. Monthly Pricing of Case Study Services

Service	Port Speed (Mbps)	Mean CIR (Mbps)	Monthly Price
E-Line	10	3	$1500
	100	50	$2500
	1000	100	$4000
E-LAN	10	2	$1200
	100	20	$1800
	1000	100	$3500
MPLS VPN	10	2	$1500
	100	15	$10,000
	1000	80	$30,000

The service price is driven primarily by the mean CIR because it is directly related to the value of the service delivered. Port speed is much less important because there is a trend toward a standard universal port. For example, 10- and 100-Mbps ports are supported through a single 10/100 interface, and 1000 Mbps uses a Gigabit Ethernet interface. Cisco expects hardware economics to accelerate the market toward a standard 10/100/1000 interface. Also, the MPLS VPN services modeled here are offered at much higher CIR than existing services that tend to use CIRs below 1 Mbps.

The assumptions for service penetration rates in the metro areas over the five-year interval are presented in Table 3.

Table 3. Service Penetration Rates Assumed for the Case Study

Service	Year 1	Year 2	Year 3	Year 4	Year 5
E-Line	3%	5%	7%	10%	15%
E-LAN	2%	3%	5%	8%	11%
MPLS VPN	1%	1%	2%	2%	3%

E-Line has highest penetration because it will find wide application for Internet access service. MPLS VPN has the lowest penetration because it is a premium service (with associated high price) and operates at CIRs well above those of existing MPLS VPN offerings.

The distribution of the ports by type and data rate over the five-year interval is depicted in Figure 3.

Figure 3

Ethernet Port Distribution in the Case Study

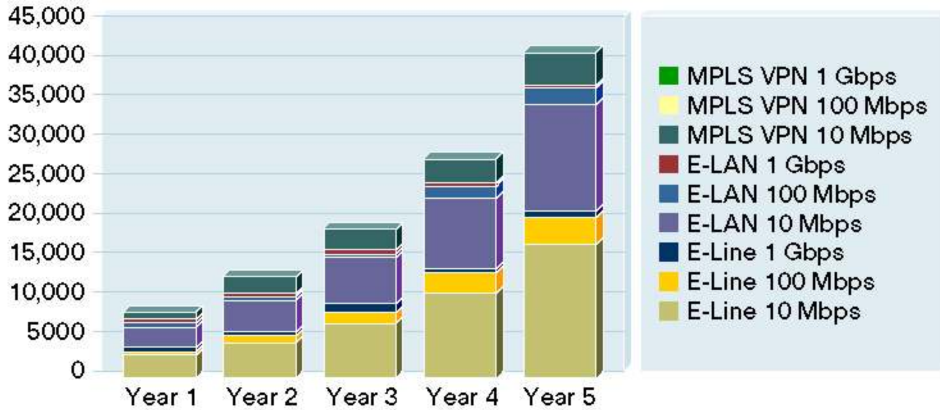


Figure 3 shows the distribution by number of ports. 10-Mbps ports dominate the distribution because there are many more small business establishments that require 10-Mbps ports than very large establishments with 1-Gbps port requirements. Also, initial service offerings have emphasized Gigabit Ethernet offerings, so the relative share of lower-speed ports increases over time as the much larger sales and distribution programs serving smaller establishments gear up. E-Line is expected to be the best-selling service because it will become the preferred method for enterprise Internet access service, which has the broadest market appeal, as well as finding increasing favor as a high-speed method for accessing IP service nodes. E-Line is also used for wholesale services, which continue to grow in popularity. Although MPLS VPN has the smallest share of total ports, it carries the highest monthly recurring price as befits its positioning as a premium managed IP service offering.

Network Architecture for the Case Study

In this case study Cisco Carrier Ethernet products are used in the network. These products use a combination of Layer 2 Q-in-Q switching, Layer 2 VPLS and VPWS, and Layer 2 MPLS VPN to deliver the services described previously. All the metro areas are interconnected with an international MPLS backbone.

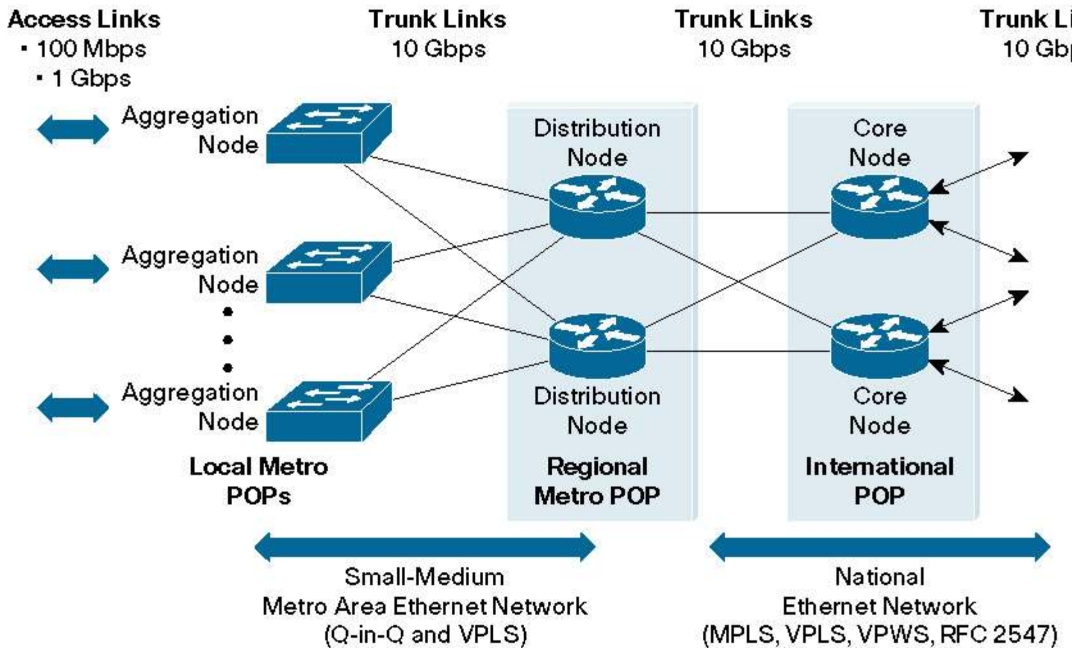
The case study uses three types of nodes:

- Aggregation nodes
- Distribution nodes
- Core nodes

The aggregation nodes are used for Ethernet access and operate as Layer 2 switches using Q-in-Q. The distribution nodes function both as Layer 2 switches and as MPLS Layer 3 routers. The core nodes make up the Layer 3 MPLS backbone. In this study it is assumed that the Carrier Ethernet networks must be built from the ground up. Therefore all switches and routers are considered part of the CapEx. However, it is assumed that the MPLS backbone is already in place. Thus, the additional expenses associated with the core nodes are limited to the 10-Gigabit Ethernet cards required to provide Carrier Ethernet access to the international MPLS backbone. Access lines are provided with 10/100/1000 Mbps fiber-optic interfaces on the aggregation nodes, and all trunks use 10 Gigabit Ethernet.

Figure 4 illustrates the network design modeled for a medium metro area.

Figure 4
Network Design for a Medium Metro Area

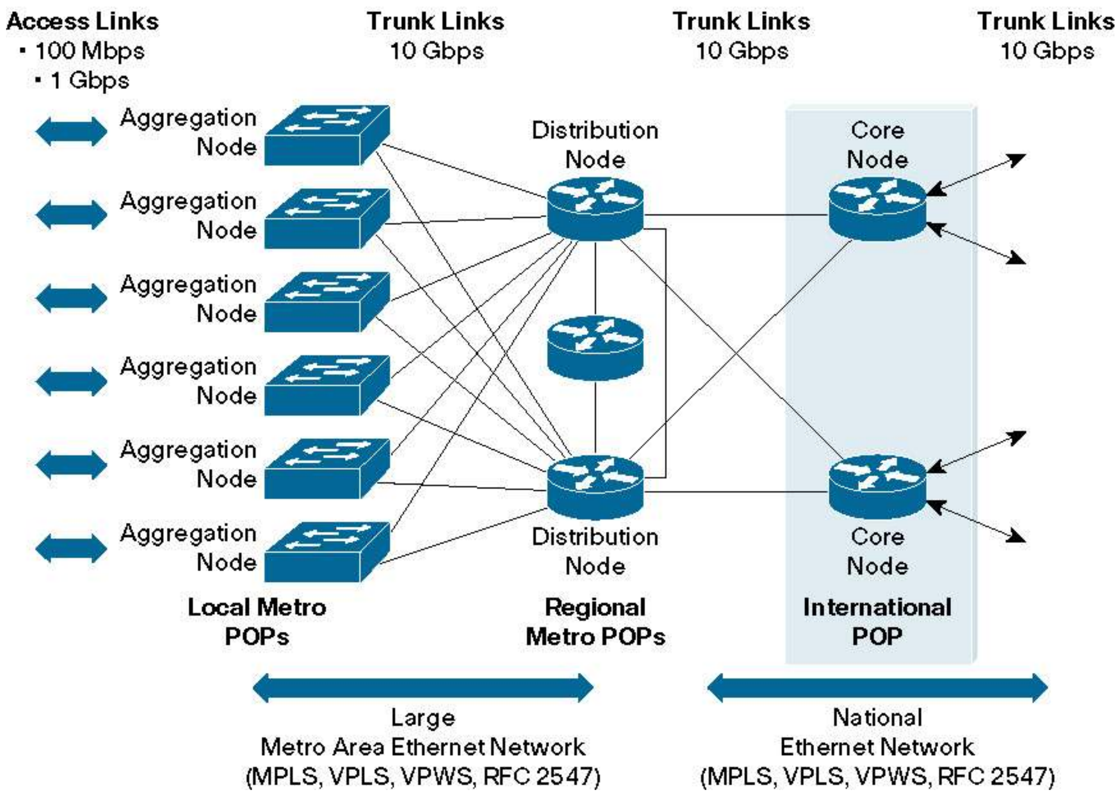


In medium metro areas, access lines are aggregated by aggregation nodes in local POPs. Local POPs are then connected to distribution nodes in a single regional POP. It is assumed that two distribution nodes with dual access connections to aggregation nodes are used in all regional POPs for high availability. In this case study there are five local POPs and one regional POP in the medium metro area.

Figure 5 illustrates the network design modeled for a large metro area.

Figure 5

Network Design for a Large Metro Area



In large metro areas, access lines are aggregated by aggregation nodes in local POPs. Local POPs are then connected to distribution nodes in multiple regional POPs. The access lines are aggregated using Layer 2 Q-in-Q and the regional POP network supports VPLS, VPWS, and Layer 3 MPLS VPN (RFC 2547bis). It is assumed that two distribution nodes with dual access connections to aggregation nodes are used in all regional POPs for high availability. There are 20 local POPs and 3 regional POPs in the large metro area.

Business Case Results

Revenue, operations expenses, and capital costs, and discounted cash flows are calculated using the assumptions specified previously and are presented in Table 4.

Table 4. Revenue, Operations Expenses, and Capital Costs

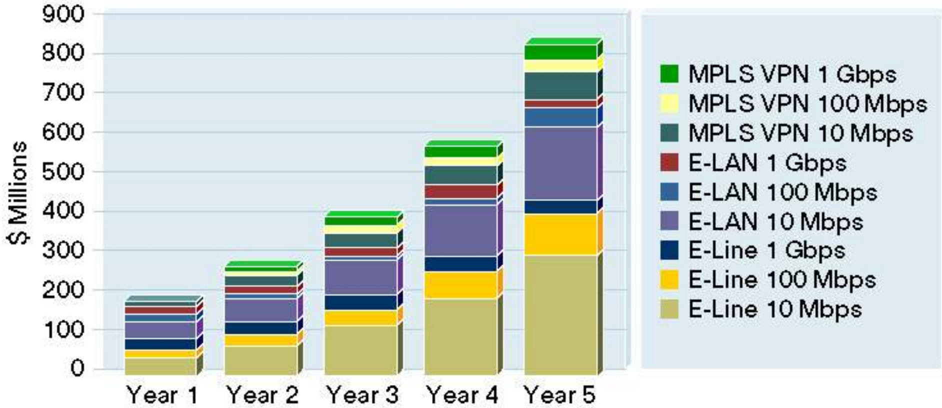
	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Revenue					
E-Line	$ 99,540,000	$ 144,963,000	$ 210,924,000	$ 306,605,250	$ 445,236,750
E-LAN	$ 56,651,368	$ 83,180,558	$ 122,076,095	$ 179,072,029	$ 262,544,874
MPLS VPN	$ 35,700,000	$ 50,887,200	$ 71,746,584	$ 100,216,946	$ 138,847,862
Annual Revenue	**$ 191,891,368**	**$ 279,030,758**	**$ 404,746,679**	**$ 585,894,225**	**$ 846,629,486**
Operations Expenses					
Cost of Revenue	$ 67,161,979	$ 97,660,765	$ 141,661,338	$ 205,062,979	$ 296,320,320
Sales, General & Administrative Expense	$ 46,053,928	$ 66,967,382	$ 97,139,203	$ 140,614,614	$ 203,191,077
Annual Operating Expenses less Amort. & Deprc.	**$ 113,215,907**	**$ 164,628,147**	**$ 238,800,540**	**$ 345,677,593**	**$ 499,511,397**
Capital Cost					
Aggregation Nodes	$ 3,629,031	$ 1,975,318	$ 1,899,105	$ 3,159,650	$ 4,701,353
Distribution Nodes	$ 311,480	$ 87,360	$ 14,560	$ 101,920	$ 87,360
Core Nodes	$ 617,415	$ 68,602	$ 274,407	$ 274,407	$ 343,008
Annual Capital Cost	**$ 4,557,926**	**$ 2,131,279**	**$ 2,188,072**	**$ 3,535,977**	**$ 5,131,721**
Annual Cash Flow	**$ 74,117,535**	**$ 112,271,332**	**$ 163,758,067**	**$ 236,680,656**	**$ 341,986,368**
Discounted Cash Flows	**$ 74,117,535**	**$ 105,916,351**	**$ 145,744,096**	**$ 198,721,642**	**$ 270,885,235**
Cumulative Discounted Cash Flows	**$ 74,117,535**	**$ 180,033,886**	**$ 325,777,982**	**$ 524,499,624**	**$ 795,384,860**

The cash flow analysis presented in Table 4 examines the revenue and direct operating costs associated with the case study's service rollout. Nonoperating items, including depreciation, amortization, income taxes, and interest expense, are excluded from the analysis. The discount rate is 6 percent. The only CapEx included are for the Cisco switch and router equipment. The operations expense calculations are derived from the MEF's operating expense case study as well as Network Strategy Partners' analysis of the SEC filings of U.S. wireline carriers.[7]

[7] "Service Provider Business Case Study: Operating Expenditures," January 2004, Metro Ethernet Forum, http://www.metroethernetforum.org/PDFs/WhitePapers/Provider-Business-Case-OpEx-Study-Summary.pdf

Figure 6 charts the case study's revenue distribution.

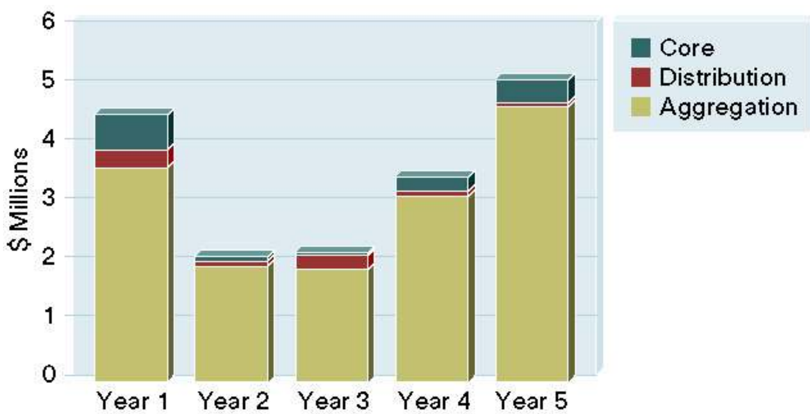
Figure 6
Revenue Distribution



The 10-Mbps services make the largest contribution to total revenue, as would be expected from the port distribution projections. A cost-effective access network is essential because many small establishments must be served to capture this revenue.

Figure 7 charts the CapEx for switching and routing equipment.

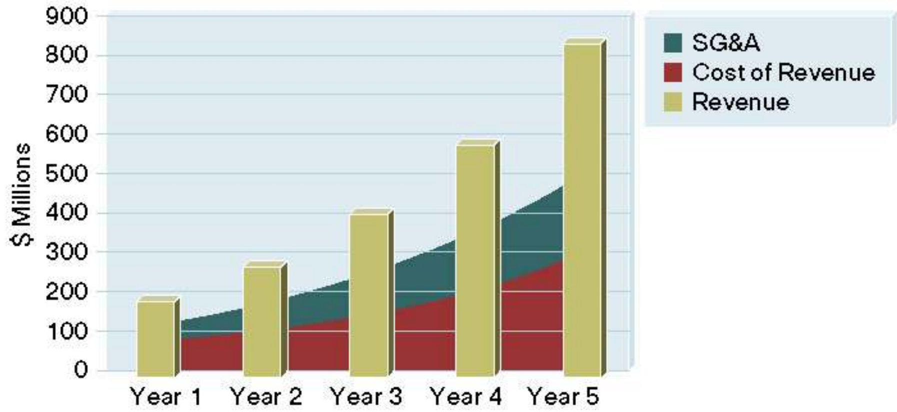
Figure 7
Capital Expenditures



The total cost for switch and router equipment is US$17.5 million. This is a modest expenditure compared to the project's net present value of discounted cash flow of US$795 million. Most of the CapEx is for the aggregation nodes used in the access portion of the network. Because access accounts for much of the total CapEx, low-cost Layer 2 Q-in-Q switching significantly reduces overall CapEx requirements.

Figure 8 compares operating expenses to revenue.

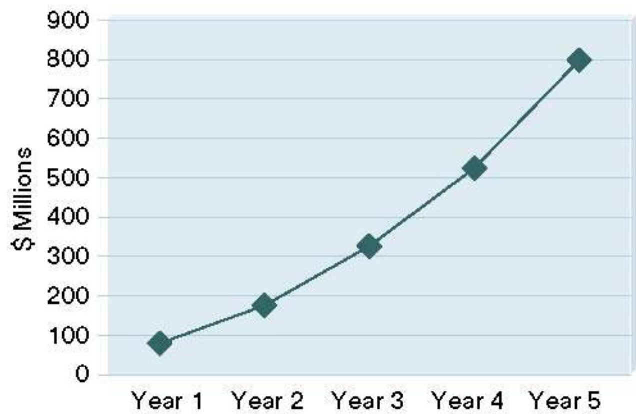
Figure 8
Comparison of Operating Expenses and Revenue



The Carrier Ethernet and MPLS technologies used for service delivery reduce the cost of revenue directly by eliminating many network add, move, and change procedures and by simplifying network operations, as was discussed in preceding sections. In addition, sales, general, and administrative (SG&A) expenses are reduced by making services easier to configure and by reducing the interval between sales initiation and service turnup.

Figure 9 shows the case study's cumulative discounted cash flow.

Figure 9
Cumulative Discounted Cash Flow



Carrier Ethernet projects produce strong contributions to service provider cash flow and provide significant help in resolving wireline carriers' current strategic issues as they move to converged network solutions.

Conclusion

As service providers struggle with the challenges of fundamental paradigm shifts in the industry, Carrier Ethernet and MPLS VPN services provide a route to profitable high-growth service offerings. Cisco provides the widest array of products for Carrier Ethernet and MPLS VPN, using a variety of technologies, including:

- IEEE 802.1 Q-in-Q
- VPLS
- VPWS
- RFC 2547bis MPLS VPN

Using Cisco products, you can build a profitable data network with reasonable levels of capital investments and highly efficient operations.

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