



Extending Ethernet Over the WAN

Business Guide to Ethernet Options for
Converged Networks

Building an ROI Application & Network Performance Management

Table of Contents

Abstract	3
Introduction	3
The Secret to Ethernet's Long-Term Success	4
Ethernet Advantages	4
The Metro Ethernet Forum: Setting Direction	5
Carrier Ethernet Network Services	6
Ethernet Private Line (EPL)	6
Ethernet Virtual Private Line (EVPL)	7
Ethernet Private LAN	8
Virtual Private Wire Service (VPWS)	9
Virtual Private LAN Service (VPLS)	9
Success Stories of Early Adopters	10
Education	10
Financial Services	10
Healthcare	10
Manufacturing	11
Ethernet Infrastructure Deployment Options	11
Mid-Band Ethernet (Ethernet over Copper)	12
Ethernet over DS-1 or DS-3	12
EFM Fiber (EFMF)	12
EFM PON (EFMP)	12
Wireless Carrier-Class Ethernet	12
Which Ethernet Solution is Best for You?	13
What to Look for when Choosing an Ethernet Service Provider	13
Conclusion	14
References	14
XO Communications	15
About Shepard Communications Group, LLC	15

Abstract

Ethernet is one of the most widely deployed networking options in the world today. The purpose of this paper is to explain why this technology remains so popular and to help medium to large-sized businesses select what Carrier Ethernet solution is best for their needs. The paper presents a range of Carrier Ethernet service options, all of which use existing infrastructure and support convergence. Additionally, the paper explains how several vertical

industries (education, financial services, healthcare, and manufacturing) have optimized their Ethernet investments by extending Ethernet over the Metro and Wide Area Network (WAN). Infrastructure deployment options are discussed, as well as criteria for choosing an Ethernet solution and service provider. In an increasingly converged networking universe, where the diversity of traffic demands not only high bandwidth but also Quality of Service (QoS), Ethernet has emerged a winner.

“The purpose of this paper is to explain why Ethernet technology remains so popular and to help medium- to large-sized businesses select what Carrier Ethernet solution is best for their needs.”

Figure 1: The developmental cycle of most telecom technologies follows the shape shown.

Introduction



In the first stage (A), a steep climb up the left side of the curve represents the initial introduction of the technology and the fierce battle to establish credibility and relevance among other competing technologies. As the curve wraps across the top of the mesa (B), it flattens — a sign that it has achieved not only market presence, but also critical mass and market saturation. Finally, most technologies reach a point where they begin the long, slow, inevitable slide into oblivion (C) as they are replaced by newer technologies that offer a better cost-benefit performance ratio than their predecessor.

Once in a great while, however, a technology comes along that doesn't follow this developmental cycle. Instead of reaching a point where decline is imminent, the technology surprises the market, passing through a period of reinvention and adaptability that initiates another growth phase (D) and reinvigorates the technology in the mind of the market.

“In an increasingly converged networking universe, where the diversity of traffic demands not only high bandwidth but also QoS, Ethernet has emerged as one of the most widely deployed networking options in the world today.”

Ethernet is one of these technologies. Originally announced in 1976 by Xerox at their Palo Alto Research Center (PARC), it has gone through multiple reinventions, and even though it is now 31 years old (downright ancient by today’s technological standards), Ethernet remains as vigorous, adaptable, and relevant as it was when it was first introduced. Why? Because it continues to do precisely what it was originally designed to do — distribute data around local networks, be it coaxial cable, Cat 5, fiber optics, or radio waves (hence the term “ether” to describe some undefined path), while remaining flexible enough to incorporate improvements without challenging its fundamental design.

The Secret to Ethernet’s Long-Term Success

Originally crafted to transport enterprise LAN traffic and effect the sharing of expensive network resources, Ethernet is now going beyond the LAN as a preferred last-mile and Wide Area Networking (WAN) service to support Voice over IP, IP VPNs, video applications, and other high-traffic applications. In the years since its introduction, Ethernet has evolved from a relatively primitive networking technology to a sophisticated, very high bandwidth solution for the transport of every kind of media traffic. In an increasingly converged networking universe, where the diversity of traffic demands not only high bandwidth but also QoS, Ethernet has emerged as one of the most widely deployed networking options in the world today.

Ethernet Advantages

The demand for more bandwidth with Ethernet services continues to grow. In fact, experts predict that by 2011 the number of mid-band U.S. business Ethernet ports is expected to increase sevenfold (from 100K to 700K ports), and the number of high-speed Ethernet ports is expected to be at least six times greater than it is in 2007 (from 50K to 300K ports).¹ Why such demand? Consider the advantages of Ethernet:

Ethernet Advantages

- Familiar
- Simple
- Supports diverse QoS
- Universal interoperability
- Uses existing infrastructure
- Cost-effective
- Supports diverse bandwidth
- Supports convergence

- Familiarity – Because Ethernet has been around a long time, IT personnel are comfortable with its capabilities and are, therefore, willing to accept its use with minimal pushback.
- Simplicity – A single Layer 2 protocol connects everything, eliminating the need for complex protocol conversions to bring about connectivity.
- Support for Diverse QoS Levels – As network traffic becomes more diverse, it demands support for multiple levels of QoS. Inherent in the Ethernet protocol is a field specifically assigned to carry QoS information, giving Ethernet the ability to support varying traffic flows according to application. These range from a best-effort service for low-priority data flows such as e-mail, to the very high-priority requirements of voice and video.
- Universal Interoperability – As the telecom world’s attention has slowly focused in on IP as the “uber-protocol” of the future network, MultiProtocol Label Switching (MPLS) has emerged to guarantee IP’s ability to deliver effective QoS across the IP-based WAN. Ethernet’s QoS capabilities mesh seamlessly with the capabilities of MPLS, thus ensuring full interoperability between the two protocol domains. Furthermore, because IP and Ethernet are so widely deployed, they present a level of interoperability that is unequalled in the networking world. As a consequence, Ethernet is widely viewed as a “perfect access partner” for IP.

¹ Metro Ethernet Forum, “Carrier Ethernet Access: Extending Ethernet into the First Mile,” 2007, p. 5. <http://metroethernetforum.org/presentations.htm>

“The only technology that offers the breadth of bandwidth and QoS diversity of Ethernet is ATM — at many times the price.”

- Use of Existing Infrastructure – Ethernet designers have been careful to ensure that minimal infrastructure investment is required above and beyond what is for the most part already in place.
- Cost Effectiveness – Ethernet remains a cost-effective network solution because it supports legacy network integration and emerging IPbased applications — without requiring major capital outlay for a new network. And, Carrier Ethernet services can offer significant savings. For example, XO Communications estimates that 10 Mbps Internet service provisioned over Ethernet can offer cost/ Mbps that is 50% to 65% lower than legacy T1 and bonded T1 service.
- Support for Diverse and Scalable Bandwidth – Standards-compliant interfaces are available for data communication / telecommunication devices at line rates of 10/100/1000 Mbps to an impressive 10 Gbps — all at a very attractive price point. No other technology on the market can do that, except for Asynchronous Transfer Mode (ATM). In fact, the only technology that offers the breadth of bandwidth and QoS diversity of Ethernet is ATM — at many times the price. And unlike TDM-based Private Line solutions, you can deploy Ethernet without having to frequently upgrade speeds in small increments.
- Support for Convergence – Ethernet represents an ideal solution for the converged network. It interfaces seamlessly with IP and MPLS, supports diverse traffic types and their needed QoS levels, and does so within the context of a widely deployed, well understood technology that is both service and cost effective. In short, Ethernet offers the ideal solution for companies of all sizes.

The Metro Ethernet Forum:

Setting Direction Formed in 2001, the Metro Ethernet Forum (MEF) is a global industry alliance principally responsible for guiding the development of Ethernet services for the enterprise. Unique in its approach, the Forum oversees both technology (technical specifications) and marketing efforts (implementation agreements) for the development and rollout of Ethernet services. To learn more about the Forum, go to <http://metroethernetforum.org>.

MEF defines Carrier Ethernet as a *ubiquitous, standardized, carrier-class service*² that is different from LAN-based Ethernet in several ways. For example, Carrier Ethernet:

- Provides transparent, Private Line, virtual Private Line, and LAN services — globally and locally — via standardized, MEFcertified equipment.
- Enables the network to detect and recover from incidents without impacting users, meeting the most demanding quality and availability requirements. In fact, rapid recovery time is as low as 50 milliseconds.³
- Provides service management capabilities for monitoring, diagnosing, and centrally managing the network, plus rapid service provisioning, and more.
- Simplifies network management because all connected LANs can be treated as one large network, even across the country.
- Eliminates the need to purchase expensive dedicated circuits and additional transport equipment to connect sites.

In sum, Carrier Ethernet Networks have set the stage for converged networking at low cost, enabling more efficient, more economical Carrier Ethernet Network Services. Although Carrier Ethernet had its beginnings in optical Metro Ethernet, it has expanded to include access networks and is now available to a much wider class of user — over fiber, copper, cable, passive optical network (PON), or wireless.

² “What is Carrier Ethernet?” http://metroethernetforum.org/page_loader.php?p_id=140

³ http://metroethernetforum.org/page_loader.php?p_id=140

Carrier Ethernet Network Services

The Metro Ethernet Forum has defined a number of MEF Ethernet Services that form the basis of a Carrier Ethernet Network. These services can be summarily classified into two categories:

- Ethernet Line (E-Line) Service – Includes the use of Ethernet for Private Line replacement, Frame Relay replacement, and Internet Access via Ethernet Private Line or Ethernet Virtual Private Line.
- Ethernet LAN (E-LAN) Service – Extends Ethernet beyond the LAN across the metro and WAN to enable a “transparent” LAN or an Ethernet VPN. This can be achieved with a Transparent LAN, one of the earliest industry deployments, Virtual Private Wire Services, or with Virtual Private LAN Service.

For companies migrating from legacy technology (i.e., TDM Private Line, Frame Relay, ATM) to Ethernet, there are several ways the Carrier Ethernet Network can be configured, depending on your infrastructure and your business requirements. This section explains each approach.

Ethernet Private Line (EPL)

Ethernet Private Line (EPL) Service provides a point-to-point Ethernet Virtual Connection (EVC) between two end points. This solution offers the point-to-point connectivity previously provided by TDM Private Line service. As shown in Figure 2, a dedicated User Network Interface (UNI) specifies procedures and protocols between customer equipment (CE) and the Carrier Ethernet Network.

The UNI is the physical interface or port (10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps) that is the demarcation between the customer and service provider. The service provider always provides the UNI.

Ethernet Private Line service is used to support connections between sites: cross town or cross country. It is also used to replace Private Line connections frequently used to connect to the Internet. EPL can deliver a variety of service levels to accommodate the demands of disparate Service Level Agreements (SLAs). At its most basic level, EPL offers symmetrical, best-effort, two-way bandwidth between traditional 10 Mbps Ethernet systems. However, it isn't limited to this level of service, depending on the specific service provider's offering.

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Ethernet Private Line (EPL)

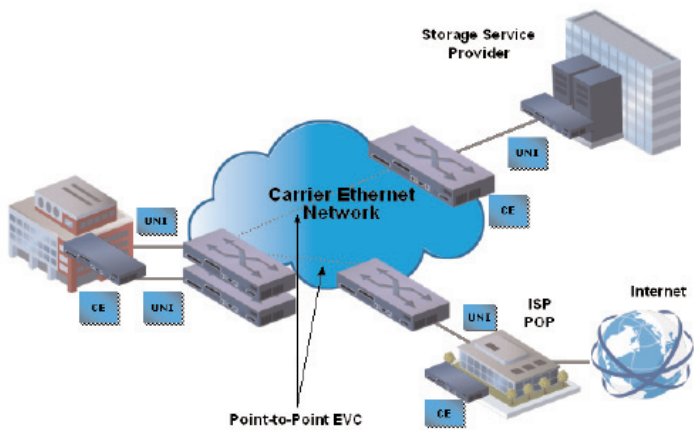


Figure 2: EPL replaces TDM Private Line and provides a point-to-point Ethernet Virtual Connection (EVC) between two end points.

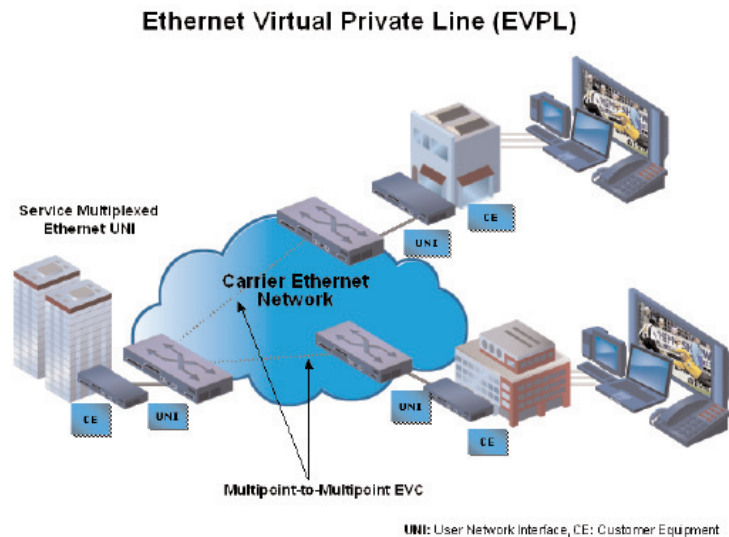
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Ethernet Virtual Private Line (EVPL)

Another major application for Carrier Ethernet is the replacement of Frame Relay or ATM through EVPL. As **Figure 3** illustrates, EVPL allows a single physical connection (UNI) at the customer equipment (CE) that will support multiple virtual connections. Depending on the specific service provider, EVPL can offer guarantees for frame loss, jitter, and delay parameters between two communicating end points.

Figure 3: EVPL replaces Frame Relay or ATM services and allows one physical connection (UNI) to customer equipment (CE) for multiple virtual connections.

Reproduced with permission of the Metro Ethernet Forum



The EVPL approach offers a number of advantages over the Frame Relay or ATM approach. In addition to ease of use and a lower price point, this Ethernet solution makes the addition of new locations easier and faster. In the Frame Relay scenario, new locations require the addition of new Permanent Virtual Circuits (PVCs). In the case of Ethernet, new locations are added to a pre-existing multipoint Ethernet Virtual Connection, thus making the process of service configuration that much more efficient.

Point-to-point connectivity, such as that offered by EPL and EVPL described above, satisfies the connectivity requirements of many company installations. However, it doesn't address the bigger picture: interconnection of LANs. For that we turn to the three Ethernet LAN (E-LAN) services described below.

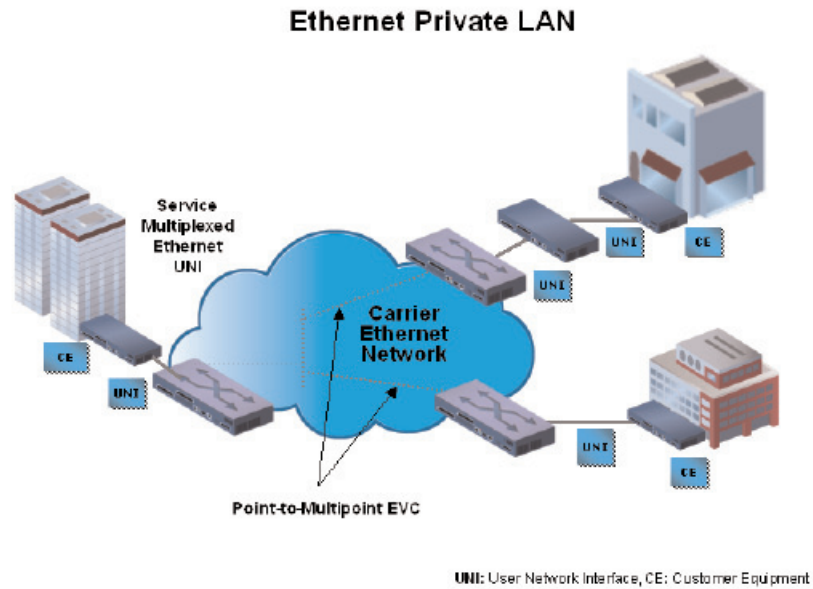
“An easy way to calculate savings that goes straight to the bottom line can be obtained by eliminating redundant tools or CPE, including equipment leases and maintenance.”

Ethernet Private LAN

In an Ethernet Private LAN network, two or more enterprise LAN interfaces are connected to the Carrier Ethernet Network to provide a “transparent LAN service,” making the network look and behave like a multipoint LAN, as illustrated in **Figure 4**. And because new locations are added to the same multipoint Ethernet Virtual Connection, the processes of provisioning and service activation are dramatically simplified and *accelerated*.

Figure 4: Ethernet Private LAN supports dedicated or service-multiplexed UNIs as well as transparent LAN services and multipoint VPNs.

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Similar to EPL, Ethernet Private LAN offers a range of service levels that support varying QoS and SLA requirements. At its most basic level E-LAN services deliver a best-effort option that offers few, if any, service level guarantees.

Virtual Private Wire Service (VPWS)

VPWS is a version of E-LAN service that many early adopters have benefited from. A typical VPWS environment is shown in **Figure 5**. VPWS delivers a common framework for the encapsulation and transport of a wide variety of Layer 2 traffic types over an MPLS-enabled IP network. In effect, it gives customers the ability to provision point-to-point circuits using Ethernet as a connection, allowing for high-speed LAN connectivity across the metro or wide area network.

Virtual Private Wire Service (VPWS)

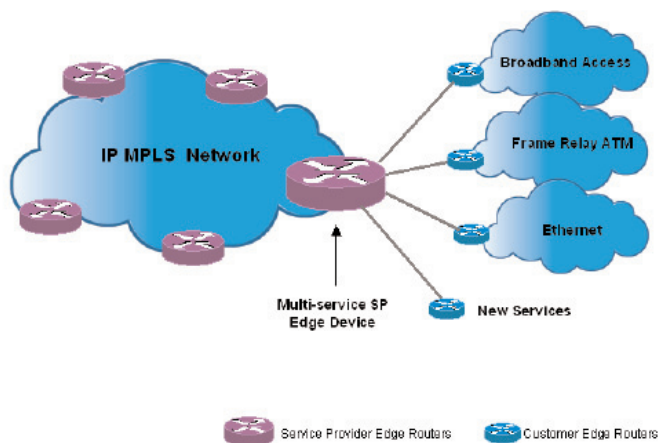


Figure 5: LAN extension using VPWS over an IP MPLS network

“Virtual Private LAN Service is ideal for such enterprise-wide applications as supply chain support, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and other centralized, diversely deployed applications.”

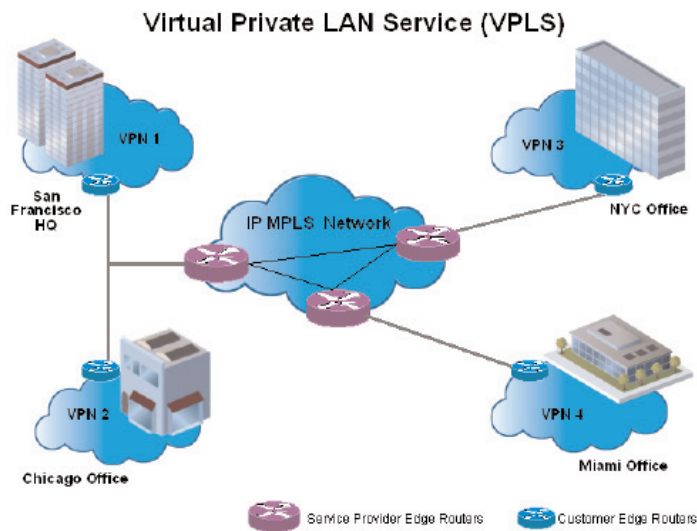
Virtual Private LAN Service (VPLS)

VPLS is the “pinnacle solution” for Ethernet in that it supports multipoint Ethernet services through packet replication and has the ability to learn and rely on source-based, Medium Access Control (MAC) addresses for point-to-multipoint VPN support. VPLS essentially allows the customer to provision a “virtual switch” (Layer 2) over an IP MPLS network (Layer 3). This arrangement, consisting of IP and MPLS in the core and Ethernet at the edge, supports connectivity among multiple enterprise locations within a metro network or across the wide area. It is ideal for such enterprise-wide applications as supply chain support, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and other centralized, diversely deployed applications.

The architecture of a VPLS installation is shown in **Figure 6**. Each customer-provisioned edge router is connected via a single connection to the local service provider edge router, which is in turn part of the IP MPLS core. The elegance of this solution is that an enterprise can continue to operate an existing Layer 2 network while at the same time exercising great control over its Layer 3-routed network and the services transported across each.

Figure 6: Carrier Ethernet offers multiple deployment options (copper, fiber, coax, wireless), enabling LAN connectivity within and between metropolitan areas in a cost-effective way.

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“Not only does Ethernet support the transport requirements of applications that have traditionally been best served by such technologies as Private Line and Frame Relay, it also lends itself to emerging IP networks, including VPNs.”

Clearly, Carrier Ethernet has been designed to satisfy the diverse and growing demands of the enterprise. Not only does it support the transport requirements of applications that have traditionally been best served by such technologies as Private Line and Frame Relay, it also lends itself to emerging IP networks, including VPNs.

Success Stories of Early Adopters

Some early adopters have been Education, Financial Services, Healthcare, and Manufacturing. How well did Ethernet meet their connectivity requirements? This section answers that question.

Education

The drivers behind the move to Ethernet in the Education market were simple: they needed a low-cost, high-bandwidth solution that would simultaneously support multiple diverse applications. The demand for a low-cost solution effectively sidelined ATM as an option, and Frame Relay didn't offer enough bandwidth — or flexibility. All roads led directly to Ethernet for support of distance learning, LAN-to-LAN wide area connectivity, transfer of large files, and Internet access. And because Ethernet was already widely deployed throughout the higher education domain as a high-speed, campus-to-campus connectivity solution, it integrated seamlessly.

Financial Services

Federal and state regulators who oversee financial institutions not only demand high levels of security, confidentiality, and privacy for customer records and transactions, but also data backup and disaster recovery. Network performance is critical in this vertical market, and QoS backed up by rigid and stringent Service Level Agreements (SLAs) is not an option. Ethernet proved to be an ideal solution for the demands of the financial services industry.

Healthcare

The Healthcare industry is encumbered by regulation that is at least as stringent as that which governs financial services. Not only must caregivers be in constant contact with one another,

but they must also have the immediate and guaranteed ability to share information with each other, sometimes in the form of very large image files (e.g., X-rays, MRIs, CAT scan results, etc). Ethernet, because of its proven performance and unerring QoS capability, is a natural fit for the healthcare industry.

Manufacturing

There is nothing trivial or unimportant about a supply chain: its failure can result in the disruption of global commerce, the alienation of customers, and opportunity losses that can quickly add up to long strings of zeroes. Corollary technologies, such as Radio Frequency Identification (RFID), a next-generation inventory tracking solution, inject massive quantities of real-time information into the overall process, further adding to the network load. Ethernet — because of its bandwidth, universality, reliability, and relative simplicity — has been accepted as an ideal solution for the transport of global supply chain information.

There are other industries using Ethernet throughout their day-to-day business operations. However, those discussed here are among the most demanding. The message is clear: if Ethernet will work in these environments, it will work in all environments.

Ethernet Infrastructure Deployment Options

Today, Ethernet is typically deployed over the following topologies:

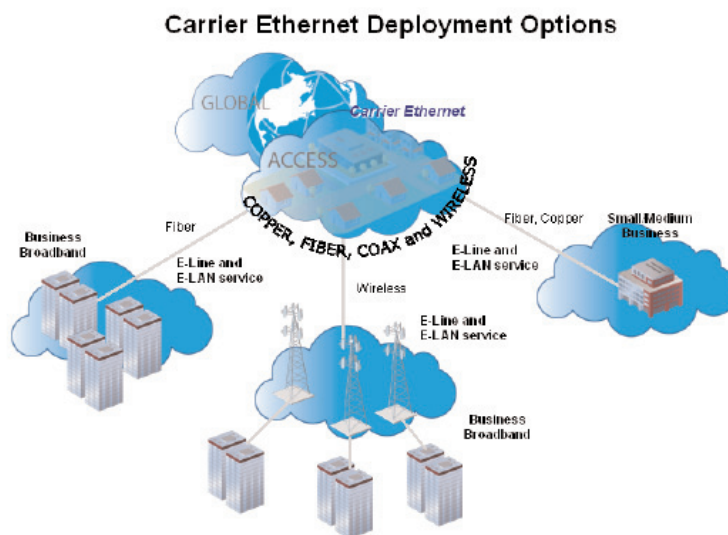
- Fiber
- Copper (loops and trunks)
- Coax
- Wireless

All four of these Ethernet deployment options have been extensively tested and deployed, and each offers advantages for the deployment situation it best serves. Furthermore, service providers can combine elements of each to create hybrid solutions for specific circumstances, as shown in **Figure 7**.

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Figure 7: Carrier Ethernet offers multiple deployment options (copper, fiber, coax, wireless), enabling LAN connectivity within and between metropolitan areas in a cost-effective way.

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“Service providers, such as XO Communications, serve thousands of commercial buildings with fiber offerings.”

Mid-Band Ethernet (Ethernet over Copper)

Thanks to legacy voice and the widespread deployment of DSL, twisted-pair copper is relatively ubiquitous throughout the first mile. Consequently, *Mid-Band Ethernet* is ideal as a deployment topology for residential neighborhoods and office complexes. Mid-Band Ethernet is a preferred solution over businessclass DSL service (768 Kbps – 6 Mbps) or T-1 (1.5 Mbps) for business customers seeking an affordable 10 Mbps solution with guaranteed throughput. Furthermore, deployment has become more widespread in the past year and is available from a number of service providers, including XO Communications. The standards for Mid-Band Ethernet are ratified and mature, and it offers a powerful and compelling option to higher cost and more complex options. Mid-Band Ethernet is an easy, affordable, and immediate solution for providing feature-rich, high-speed access and services. This is an attractive access solution because it can also coexist with ADSL, VDSL, ISDN, and PSTN in the same cables, bringing native Ethernet to the first mile over a twisted-pair access network.

Ethernet over DS-1 or DS-3

For customers beyond the distances reachable by fiber and/or copper pairs, Ethernet over DS-1 or DS-3 connections are also valid options for offering carrier-class Ethernet services and solutions. DS-1s can be bonded and handed off to SONET rings in standard 10 Mbps Ethernet, while DS-3s can be offered as standalone 44 Mbps Ethernet, or bonded to offer 87 or 100 Mbps Ethernet solutions.

EFM Fiber (EFMF)

A second option for point-to-point fiber with Ethernet is Ethernet-in-the-First-Mile-over-Fiber (EFMF). EFMF specifies up to a 10 Gbps, full duplex, single mode, fiber transmission scheme for access, using a direct point-to-point

connection from the service provider’s point of presence to the customer premises. It supports both single and dual point-to-point fiber options for 100 Mbps, 1 Gbps, and 10 Gbps access, and it delivers a cost-effective option for the replacement of T1 and T3 facilities. While not as widely available as other access technologies, it is well suited for large enterprise headquarters and data centers. Service providers, such as XO Communications, serve thousands of commercial buildings with fiber offerings.

EFM PON (EFMP)

A Passive Optical Network (PON) is a single, shared optical fiber coupled to an optical splitter, which together can feed signals over multiple optical facilities going to each subscriber. Ethernet-in-the-First-Mile-over-PON (EFMP) creates a point-to-multi-point network that supports 1 Gbps of bandwidth over distances up to 20 km. This model is most appropriate for the Cable industry.

Wireless Carrier-Class Ethernet

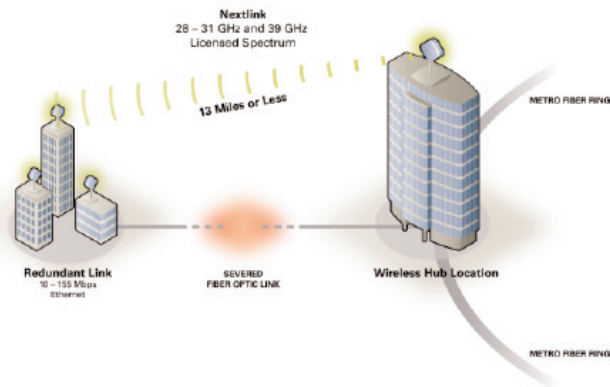
Wireless Ethernet has established itself as a killer application through the proliferation of WiFi deployed within buildings and at WiFi hotspots. Wireless Ethernet is also being deployed to support first-mile access for business locations, campuses, and municipal networks. Businesses seeking wireless Ethernet connectivity in the first mile should investigate a range of licensed and unlicensed services that have emerged over the past few years.

For those seeking interference-free, carrier-class wireless Ethernet with the highest reliability, licensed solutions are the best bet. An example of this solution is illustrated in **Figure 8**, where the service provider provides licensed wireless Ethernet as a redundant link for backup service in the event that the fiber optic link is ever severed.⁴

⁴ Eric Miller, “Engineering Highly Reliable Backhaul Networks Utilizing Licensed Microwave Spectrum,” presentation by Nextlink Wireless, 20 June 2007, p. 12.

Figure 8: Wireless Ethernet is ideally suited as a redundant backup service for Enterprises, offering a separate entrance facility not affected by fiber cuts.

Wireless Ethernet Resiliency



Source: Nextlink, a subsidiary of XO Holdings, Inc., 2007

“All too often, technologists begin with a technology and then try to back into an application for it. As a user of the technology, it is far more important to start with the need, and then determine the appropriate technology to address it.”

Which Ethernet Solution is Best for You?

All too often, technologists begin with a technology and then try to back into an application for it. As a user of the technology, it is far more important to start with the need, and then determine the appropriate technology to address it. On the road to selecting an Ethernet solution, ask yourself these questions:

- What is the business challenge that I am attempting to resolve?
- What is my budget for resolving this issue? What is the cost of not resolving it?
- Will my bandwidth and location needs change frequently in the future?
- What facilities and customer provided equipment (CPE) are already in place that I might be able to reuse, thereby eliminating the need to add costly resources?

What to Look for When Choosing an Ethernet Service Provider

The company should demonstrate that it has the following:

- A good track record with regard to technology deployment
- Extensive metro and long-haul network assets
- Well-designed service management organization
- Broad range of service deliverables
- Clear understanding of your business environment and connectivity requirements
- Option for managed solution or flexibility in supporting CPE

As an indicator of the service provider’s ability to support and deliver its advertised levels of service, the company should also meet these requirements:

- Have well-documented diagnostic, fault management and fault isolation capabilities
- Have well-trained customer support staff, field technicians, and documented procedures for problem resolution
- Rely on provisioning and control architectures that are governed by universally accepted standards
- Have standardized, well-documented network management interfaces

Conclusion

So why is Ethernet such a viable solution for the medium to large-sized enterprise? First, it has been around for a very long time and is trusted, easy to use, widely accepted and universally deployed. Second, Ethernet offers a range of QoS levels that address themselves to everything from best-effort, “get it there when you can” data traffic to “don’t even THINK about delaying this!” voice and video traffic. Third, because it interfaces seamlessly and transparently with IP and MPLS, Ethernet offers universal interoperability and will for the foreseeable future. Fourth, it can reuse pre-existing infrastructure elements, thus reducing the need for capital outlay to build a new network. Finally, Ethernet is an ideal technology for the converged network, because of all the reasons cited above.

“As enterprise traffic becomes more media-intensive and places greater demands on the network, a solution is required that will satisfy those demands, now and in the future, with appropriate QoS and service level agreement support. Ethernet has evolved to do precisely that.”

As enterprise traffic becomes more media-intensive and places greater demands on the network, a solution is required that will satisfy those demands, now and in the future, with appropriate QoS and service level agreement support. Ethernet has evolved to do precisely that.

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XO Communications is a leading nationwide provider of advanced broadband communications services and solutions for businesses, enterprises, government, carriers and service providers—and is a recognized leader in delivering Ethernet services. The company has significantly expanded the nationwide and local availability of Ethernet services, and can deliver Ethernet services to millions of locations nationwide.

The XO Ethernet Services portfolio includes:

- [XO Ethernet VPLS](#) – Multipoint-to-multipoint Ethernet WAN solution for enterprises to connect key locations, transport special applications with protocol transparency, and maintain separation of different network domains.
- [XO Ethernet Private Line](#) – Point-to-point Ethernet connectivity ideal for businesses looking for dedicated bandwidth between office locations.
- [XO Ethernet Hub](#) – Point-to-multipoint Ethernet solution ideal for connecting branches or offices to centralized headquarters or data center.
- [Ethernet Access](#) – affordable, scalable Ethernet access to deliver Dedicated Internet Access, VoIP and MPLS IP-VPN services across the enterprise.

Steven Shepard is the president of SCG, located in Williston, Vermont. He is a professional author and educator with over 25 years of varied experience in the telecommunications industry. Shepard specializes in international issues in telecommunications with an emphasis on strategic technical sales, network convergence, and the impact of emerging technologies. For more information, visit www.shepardcomm.com or call **1.802.878.0486**.



About XO Communications

XO Communications is a leading nationwide provider of advanced broadband communications services and solutions for businesses, enterprises, government, carriers and service providers. Its customers include more than half of the Fortune 500, in addition to leading cable companies, carriers, content providers and mobile network operators. Utilizing its unique combination of high-capacity nationwide and metro networks and broadband wireless capabilities, XO Communications offers customers a broad range of managed voice, data and IP services with proven performance, scalability and value in more than 85 metropolitan markets across the United States. For more information, visit www.xo.com.

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