Vertical Systems Group

Managing the Evolution of Business Services with Carrier Ethernet

Leading service providers are implementing Carrier Ethernet solutions to integrate their service platforms, increase network capacity, simplify operations and bring consistency to service delivery.

Vertical Systems Group, Inc.
www.verticalsystems.com
June 2009

Table of Contents

The Evolution of Business Services

Business network services have evolved extraordinarily during the past several decades, and the pace of change is accelerating. What hasn't changed over time is what propels these markets. On the demand side, customers make purchase decisions for network services based on price, bandwidth, connectivity and performance requirements. On the supply side, new technologies, ease of network operations and competition drive providers to expand their services markets.

Reliable, efficient transport of data and voice traffic has always been the cornerstone of business communications solutions. Customers will continue to require reliability and efficiency in the future, while their evolving business requirements dictate a need for more – more bandwidth, more connectivity and more flexibility. In this difficult economy customers also need to control their budgets and draw more value from their expenditures, with the goal of minimizing the total cost of network ownership.

Many of today's service delivery infrastructures are patchworks, which have evolved through company mergers and acquisitions, regulatory changes and technology migration. Some providers have also made strategic shifts in market focus, particularly from TDM to packet, or wireline to wireless. As a result, the challenges facing many service providers include disparate service platforms, insufficient capacity, and inadequate functionality for handling the demanding needs of business customers throughout the next decade.

Carrier Ethernet is widely accepted as the foundation for durable, "future-proof" solutions that help service providers improve today's business services, while enabling the deployment of advanced applications and capabilities. Providers worldwide have committed to Ethernet as the future standard for delivering wide area network services to their customers. Equipment vendors are supporting this significant transition with Ethernet products for business, wireless backhaul, residential, wholesale and backbone infrastructure applications.

The term *Carrier Ethernet* originated with the Metro Ethernet Forum (MEF), an industry association focused on developing technical specifications to advance the deployment of carrier-based Ethernet services. Encompassing both equipment and services, the MEF defines Carrier Ethernet as "a ubiquitous, standardized, carrier-class Service and Network defined by attributes that distinguish Carrier Ethernet from familiar LAN based Ethernet." Organizations like IEEE, ITU and IETF are also working on standards associated with Carrier Ethernet. *Business Ethernet* is the term used by Vertical Systems Group to define Ethernet network service offerings from a market perspective.

This whitepaper provides an overview of the worldwide revenue outlook for Business Ethernet services, with focus on the highly competitive U.S. market. It quantifies current business network service markets, and examines the key drivers and inhibitors for customer migration to Business Ethernet. Based on these dynamics, Carrier Ethernet deployment considerations are explored for both

near term and future implementations. From the real world perspective, AT&T and Reliance Globalcom offer insightful perspectives about the benefits of their global VPLS/MPLS Carrier Ethernet infrastructures, and the delivery of high performance Business Ethernet services to U.S. and multinational enterprises.

What is Business Ethernet?

Business Ethernet encompasses multiple network services that support point-to-network, point-to-point or multipoint-to-multipoint customer applications. Customers purchase Business Ethernet services from providers at access rates that range from 1 Mbps up to 10 Gbps. An Ethernet UNI (User Network Interface) is the Business Ethernet service demarcation between the customer and the provider network. The physical interface at the customer site is a native 10/100 Mbps or Gigabit Ethernet port on a router or switch.

There are no industry-wide standard definitions for Ethernet services, although the MEF has defined Ethernet service type generic constructs from a technical perspective (e.g., E-Line, E-LAN, etc.). Vertical Systems Group segments Business Ethernet services from a market perspective based on what service providers are offering and enterprise customers are purchasing as follows:

- **Ethernet DIA (Dedicated Internet Access)**

  Single-ended Ethernet connection from an enterprise site to an Internet Service Provider (ISP).

- **Ethernet Private Line (EPL)**

  A dedicated point-to-point Ethernet connection between two enterprise sites. EPL services include metro and long haul applications.

- **Ethernet Virtual Private Line (EVPL)**

  A dedicated point-to-point Ethernet connection that supports multiple virtual connections between two enterprise sites. EVPL services include metro and long haul applications.

- **Metro LAN**

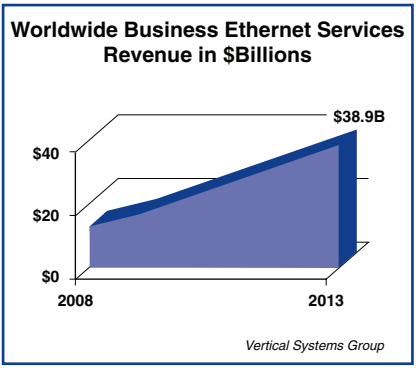
  Multipoint switched Ethernet LAN service interconnecting three or more enterprise sites within a metro area. Metro LAN services are delivered using many technologies, including VPLS (Virtual Private LAN Service).

- **Long Haul Mesh**

  Multipoint switched Ethernet wide area network (WAN) service interconnecting three or more enterprise sites. Long Haul Mesh services are delivered using VPLS or other technologies. This segment also includes Ethernet access (E-Access) connections to IP/MPLS VPN services.

Worldwide Business Ethernet Opportunity

Enterprises purchase Business Ethernet services to support high speed metro, regional, nationwide and global network applications. The benefits of using Ethernet for wide area networking clearly resonate with customers – flexibly scalable bandwidth, lower bandwidth costs, efficient application transport and simplified network management.

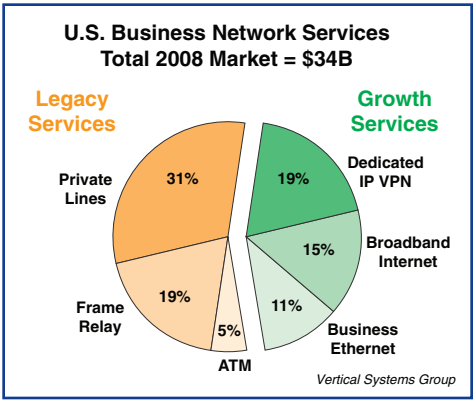


Leading service providers throughout the world are delivering or planning Ethernet service offerings to meet these customer needs. Vertical Systems Group projects strong growth for the retail Business Ethernet services market, with total revenue reaching $38.9 billion worldwide by 2013.

Asia/Pacific is the largest regional market for Business Ethernet services, representing 38% of the worldwide cumulative opportunity between 2008 and 2013. The U.S. is the second largest region based on revenue, accounting for nearly one-third (31%) of this worldwide market. Countries throughout the EMEA (Europe, Middle East, Africa) region comprise 26% of the cumulative total, and the Rest of World (RoW) region contributes 5% of projected revenue through 2013.

U.S. Business Services – Where Does Ethernet Fit?

The U.S. is the most competitive market in the world for Business Ethernet services, owing to a broad base of enterprise customers and a diverse provider environment. Business Ethernet encompasses multiple service types, including Internet access, point-to-point circuits, and VPNs. Because greenfield applications are limited, the migration of existing services is essential for expansion of the Business Ethernet market. To understand how Business Ethernet fits as a migration option, it is useful to characterize the applications and purchase drivers for each of today's major network services.



Revenue for the most widely deployed retail wireline business data network services in the U.S. totaled $34 billion in 2008. More than half (55%) of total revenue is from Legacy services, which includes

Private Lines, Frame Relay and ATM. Growth services defined as Dedicated IP VPN, Broadband Internet and Business Ethernet account for the remaining 45% of the market.

Business Ethernet contributed 11% of 2008 network services revenue and has the highest projected growth rate overall. Each of the other Growth and Legacy services is a potential migration source for Business Ethernet, as well as a competitive alternative.

- **Private Line** services are the largest business transport segment, accounting for more than $10 billion or 31% of the 2008 market. Enterprise customers rely on point-to-point legacy Private Line services to support data, voice or video applications that require dedicated connectivity and predictable performance. Customer installations range in speed from 56/64 kbps to OC-48+, with T1 circuits accounting for more than half of revenue. Price and reliability are the primary purchase drivers for legacy Private Lines. Pricing is based on the circuit speed plus the mileage between customer sites. T1 is the most widely purchased speed because the next standard incremental circuit rate is T3 (45 Mbps), which is significantly more costly.

  Revenue for this sizeable market has leveled off in recent years due to declining prices across all speeds, coupled with plunging demand for lower speed circuits. The most acute price reductions are for T3 and higher speed metro services, which compete directly with metro Ethernet Private Lines (EPLs) and Virtual Private Lines (EVPLs). In contrast, the pricing pressures for long haul circuits are fewer due to the spottier availability of WAN Ethernet EPLs and EVPLs. Pending more long haul Ethernet point-to-point alternatives, market demand is projected to sustain legacy Private Line revenue as customers upgrade to higher priced, higher speed circuits.

  An estimated 40% of Private Line bandwidth is allocated to Non-IP applications like legacy voice or video. These applications could be migrated to an Ethernet Virtual Private Line (EVPL) with a separate virtual circuit for each application, or accommodated by emerging multi-class service offerings. The capability to specify multiple classes of service (CoS) per virtual circuit handles the different performance requirements (e.g., best effort, real-time, etc.) of each application. Customers may also gain efficiencies through the consolidation of multiple legacy Private Lines onto a single EPL or EVPL.

- **Frame Relay** services generate 19% of total business services revenue. As a Layer 2 service, Frame Relay is used to support multiple protocols or applications, although nearly all of today's traffic is IP data. Customer installations range from 56/64 kbps to T3 ports, with most configurations at T1 or lower speeds. Like Private Lines, T1 is the largest source of revenue for Frame Relay services.

  Frame Relay services platforms consist of multi-layer network architectures, typically using a backbone IP/MPLS or ATM network. Customers use PVCs

(Permanent Virtual Circuits) to predefine connectivity and bandwidth, enabling customers to construct network configurations of up to thousands of locations. However, this process is unwieldy even for medium size networks, as well as costly because most providers charge for PVCs. For larger Frame Relay networks, hub and spoke or partial mesh topologies are most typical.

The current Frame Relay customer base includes nearly 15,000 U.S.-based data networks with more than ten sites. Many of these networks are global, with one or more additional sites outside the U.S., supplied by a U.S.-based or global Frame Relay services provider.

This mature market peaked in 2005, and has been in decline since then as enterprises migrate some or all of their Frame Relay sites to Dedicated IP VPNs. Service conversions have increased for several reasons. First, is the shift in customer traffic to nearly all IP, from a mix of legacy data protocols (e.g., IPX, SNA, etc.). Customers are also migrating to IP VPNs to gain more cost effective site interconnectivity, or because their applications require more bandwidth. Another major driver is VoIP, which is a prime application "trigger" for service migration from Frame Relay to IP VPNs.

Initially introduced as a service in 1991, Frame Relay installations grew rapidly due to migration from legacy Private Lines. Customers used point-to-point circuits to build private wide area networks that interconnected bridges or routers located at remote sites. As these configurations grew to include more locations, they became costly and complex to manage. By replacing long haul Private Lines with multiplexed local access connections to a Frame Relay service "cloud", enterprise customers simplified network management, improved bandwidth utilization, and reduced costs as much as 40% and more. Savings were largely achieved due to the differential between mileage-based Private Line pricing and distance-insensitive Frame Relay port pricing. Additional savings were realized through reduced requirements for multiple local access lines and WAN router ports.

Frame Relay migration to Ethernet is increasing, driven by customer demand for scalable bandwidth above T1. Ethernet Metro LAN or WAN VPLS services are the primary alternatives, dependent upon the bandwidth needs and geographic scope of the network. For enterprises accustomed to maintaining control of their network configurations, Layer 2 VPLS services may be a better fit than Layer 3 IP VPNs. Interest is particularly high for WAN VPLS "cloud" offerings that are functionally a good match. In addition to VPLS, providers are using hybrid WAN VPLS / IP VPN solutions as an Ethernet migration path for customers with Frame Relay or Frame Relay/ATM networks.

- **ATM** (Asynchronous Transfer Mode) revenue accounts for 5% of the total U.S. business market. ATM is a broadband service that uses a fixed length packet technology. Customer installations are from T1 to OC-48, with the majority of ATM revenue derived from T3 services.

Customers use ATM as a backbone network that has QoS (Quality of Service) to support a mix of applications with different traffic characteristics (e.g., variable bit rate IP, constant bit rate video, etc.). ATM services were initially positioned to replace Frame Relay, but most customers could not cost-justify service migration to ATM. Customers currently use ATM primarily for broadband applications or for the aggregation of lower speed Frame Relay ports.

ATM revenue has declined sharply due to the availability of metro Business Ethernet and other services offering higher speed, lower cost bandwidth options. A more complex migration scenario is larger Frame Relay/ATM configurations, which tend to be nationwide or global networks. One solution is a hybrid configuration that uses Layer 3 VPN services to connect lower speed Frame Relay sites and Layer 2 VPLS services for the higher speed ATM locations.

- **Dedicated IP VPN** services comprise 19% of the U.S. business market. This segment includes Network-Based MPLS offerings and Site-to-Site services. IP VPN port speeds start at 56 kbps and scale up to Gigabit rates. IP VPN services are delivered using many different access technologies, so these services are nearly ubiquitous worldwide. T1 is the most widely deployed connection rate, and the largest source of U.S. Dedicated IP VPN revenue.

  The primary driver for IP VPN purchases is the rapid rise of peer-to-peer business IP applications that require any-to-any wide area interconnectivity. Customers purchase Network-Based IP VPN services to ensure high network reliability, security and performance, backed by Service Level Agreements (SLAs). Network-Based IP VPNs have more aggressive SLAs as compared to Site-to-Site IP VPNs because the provider controls the service infrastructure, which is typically an MPLS backbone. As a result, enterprises implementing VoIP, a major IP VPN purchase driver, typically rely on Network-Based offerings to support business-quality voice applications.

  Frame Relay is a top migration source for Dedicated IP VPN services. A benefit of Layer 3 IP VPN services for customers migrating from Frame Relay is the ability to use IP addressing, which reduces PVC management issues and costs. Most Frame Relay networks are not highly meshed, but as customer connectivity requirements expand, an IP VPN may be a more practical service alternative.

  The outlook for the Dedicated IP VPN market is double-digit annual growth through 2013. Within the next year, the number of Dedicated IP/MPLS VPN customer sites in the U.S. is projected to surpass installations of Frame Relay/ATM network services. Increased availability of E-Access connectivity to IP VPN services is also driving growth of this market. Using Ethernet access connections to their existing IP VPNs, enterprises can incrementally increase bandwidth speeds at selective sites without the disruption of migrating the entire network to a new service technology.

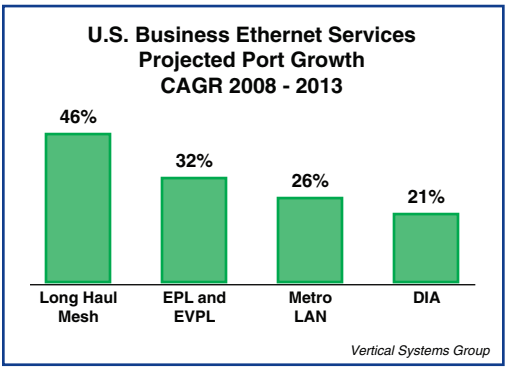
- **Broadband Internet** contributed 15% of 2008 services revenue. Millions of broadband access lines connect U.S. business sites to the public Internet using Business DSL or Business Cable Modem services. Broadband dedicated Internet access services are also used as the wide area network infrastructure for "Do-It-Yourself" (DIY) VPNs that are managed by enterprises. Download speeds for DSL services average 2 Mbps, but range from below 1 Mbps up to about 8 Mbps, depending upon the technology offered by the provider. Cable Modem services typically deliver broadband rates from 2 Mbps to 6 Mbps.

  Enterprise purchase decisions for Broadband Internet services are based on availability, bandwidth and price. Providers price and package business-class DIA offerings with additional features and 'better' effort than best-effort residential DSL and Cable Modem services.

  On-net business Ethernet DIA services provide "even better" Internet access, and are competitively priced based on bandwidth costs per bit. 10 Mbps and lower speed Ethernet DIA services compete directly with business-class DSL and Cable Modem services. Higher speed Ethernet DIA offerings are service alternatives to T3 or OC-3 IP circuits.

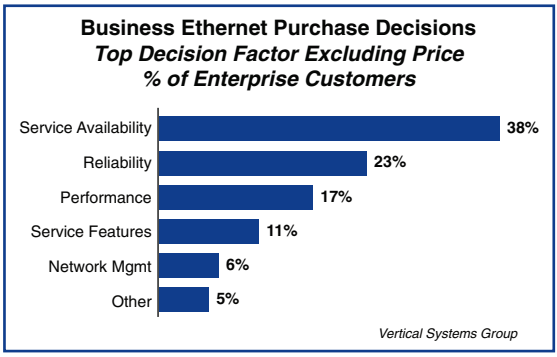
- **Business Ethernet** revenue is derived from Long Haul Mesh, Ethernet Private Line (EPL), Ethernet Virtual Private Line (EVPL), Metro LAN and Dedicated Internet Access (DIA) services. Each of these service segments addresses a distinct set of customer requirements.

  - **Long Haul Mesh** services are purchased by enterprises to support Ethernet wide area network configurations that interconnect three or more sites. This service segment includes WAN VPLS ports, plus E-Access port connections to IP/MPLS VPN services. The base of Long Haul Mesh customer ports is relatively small now, however this is the fastest growing Business Ethernet segment overall based on projected port installations. The compound annual growth rate (CAGR) for Long Haul Mesh ports is 46% between 2008 and 2013. Common applications for Long Haul Mesh services include IP convergence and migration for Frame Relay/ATM networks. VPLS pricing is typically determined on an individual case basis, dependent on the geographic scope of the network, port rate, SLA requirements, and features.



- **Ethernet Private Line** (EPL) and **Ethernet Virtual Private Line** (EVPL) services support metro or long haul applications. Enterprises purchase these services to replace legacy Private Lines, support new point-to-point applications, or to implement hub-and-spoke networks. The EPL & EVPL port base is projected to grow at a CAGR of 32% between 2008 and 2013. Typical EPL speeds are from 10 Mbps up to 10 Gbps, with some providers also offering Sub-10 Mbps EPLs (e.g., 4 Mbps, etc.). Ethernet Virtual Private Lines add additional flexibility to EPLs, allowing for the transport of multiple services over separate EVCs (Ethernet Virtual Connections) on the same physical connection. Through the use of multiple service classes, EPLs and EVPLs can support the specific requirements of different traffic types. Like legacy circuits, pricing for Ethernet circuits is based on the distance between customer sites and the speed of the connection. EVPLs are typically priced like EPLs, with additional charges for each EVC.
- **Metro LAN** services are used to interconnect three or more enterprise sites within a metro area. The outlook for Metro LAN port growth in the projection time period is 26%. Purchase decision factors for Metro LANs include price, service availability, application performance, security and network management. Pricing per site for Metro LAN services is based on the port speed plus service features. A standard SLA may be included in the base price for offerings managed by the provider, or for protected services using Ethernet over SONET.
- **Ethernet DIA** is the largest segment based on installed ports due to broad service availability, competitive pricing and ease of migration. Port growth for the Ethernet DIA segment is projected at a 21% CAGR between 2008 and 2013. Access rates for Ethernet DIA services range from as low as 1 Mbps up to 10 Gbps. The most common Ethernet DIA port rates purchased by enterprise customers are 10 Mbps and 100 Mbps.

Demand vs. Supply: Business Ethernet Purchase Decisions



Although customer demand for wide area Business Ethernet services is solid, the market is supply-constrained. More than one-third (38%) of enterprise customers cited service availability when asked, *"Other than price, what is your top decision factor when purchasing Business Ethernet Services?"* Reliability is the top consideration after price for nearly one-quarter (23%) of customers, while others cited performance (17%), service features (11%), network management (6%) and other issues (e.g., existing provider, standards, etc.).

Business Ethernet service availability is linked directly to fiber availability. Direct fiber is the preferred access technology used for Business Ethernet service delivery due to the advantages of uncomplicated provisioning, operational simplicity and flexible bandwidth scalability. Consequently, Business Ethernet revenue correlates with customer accessibility to fiber. Asia/Pacific is the largest regional market for Business Ethernet due to the high density of fiber within major business areas, particularly in Japan, Korea, Hong Kong and Singapore.

In the U.S., fiber build outs have appreciably increased in the past five years. Currently 19.1% of commercial buildings in the U.S. with 20 or more employees are fiber-fed by a network provider, up from 10.9% in 2004. Enterprise locations with no access to fiber facilities comprise the "Fiber Gap". Fiber – plus speed and pricing – comprise the "Big 3 Ethernet Services Market Gaps".

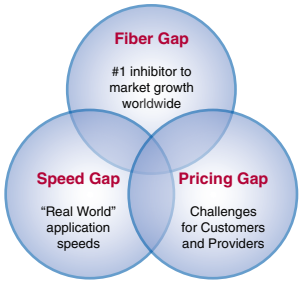
In response to customer demand, filling the **Fiber Gap** is a priority for Ethernet providers. Direct fiber currently accounts for half of existing U.S. Business customer installations. When direct fiber is not available, the next most utilized access option is SONET/DWDM. Other alternative solutions for delivering Ethernet to customers in the U.S. include Bonded T1, Bonded Copper, T3, Coax/HFC, wireless and other technologies. The mix of access solutions varies by Ethernet provider and is dependent on costs to deploy, operations costs and market strategies.

The **Speed Gap** refers to the divergence between T1, which is the prevalent service speed used by U.S. customers, and the 10 Mbps entry speed for native Business Ethernet. In the LAN environment, 10/100Mbps and Gigabit bandwidth is a fixed capital expense, however WAN bandwidth is a monthly recurring expense, and the higher the access speed, the higher the cost. More than 90% of all U.S. business

service access connections are 2 Mbps or lower speeds. To fill in the Speed Gap, customers require Business Ethernet offerings starting at Sub-10 Mbps rates.

A challenge for both service providers and customers is the **Pricing Gap**. Providers are grappling with many strategic pricing decisions, particularly how to position new Ethernet services relative to their existing offerings. At the same time, customers have varying perceptions of how Ethernet pricing compares to the costs of their existing services. It is difficult for customers to compare prices without issuing an RFP because there are no standard service definitions and list pricing is generally unavailable. Based on the average price per bit for bandwidth, most Business Ethernet offerings are priced well below what customers are already paying for their existing network services. Albeit the boost in bandwidth that Ethernet services provide, the bottom line for customers is the impact on their monthly service costs. Total recurring cost of ownership is especially a challenge for customers with larger networks. For example, the incremental cost of upgrading a single site from T1 to 10 Mbps Ethernet is easier on the budget than upgrading every site from T1 to 10 Mbps Ethernet in a network that has hundreds of locations.

Big 3 Ethernet Services Market Gaps



Vertical Systems Group

Carrier Ethernet Deployments: 2009 - 2010

To address Business Ethernet customer demand during the next year, Carrier Ethernet initiatives for service providers will center on filling fiber gaps, expanding geographic service coverage, upgrading metro and core infrastructures, and rolling out nationwide or global VPLS. Best practices for Business Ethernet service delivery are illuminating the importance of the service platform, particularly its scalability to address increasing customer demand for Long Haul Mesh services.

VPLS/MPLS is being widely deployed by major providers delivering Business Ethernet services. Deployment models rely on one of two types of signaling; Label Distribution Protocol (LDP) or Border Gateway Protocol (BGP). A primary difference is ease of provisioning. With LDP-based VPLS implementations, the provider manually engineers point-to-point virtual connections through the network to establish a full mesh between customer sites. A Layer 2 control protocol such as spanning tree can be optionally provisioned to prevent loops from forming. For BGP-based VPLS implementations, this is accomplished through an auto discovery process where connections are automatically setup to form a loop-free topology between customer locations.

Virtual LANs (VLANs) define logical connectivity groups within a customer's network. If the customer edge device at the user network interface (UNI) is a router, then the provider network receives a single MAC (Media Access Control) address. If the customer connects using a switch, the network provider is responsible for handling the customer's MAC addresses. In this case, customers may be restricted by the provider to a fixed number of MAC addresses per site. Business Ethernet providers have different policies and pricing for MAC address use. Currently, the vast majority of enterprises use routers, which service providers encourage because it simplifies provisioning and management.

The LDP model is prevalent within metro areas where network domains are geographically limited and customer applications for Ethernet typically connect fewer than ten sites. BGP implementations are operationally more functional for scaling to the delivery of large nationwide or global customer networks with hundreds of sites or more. Because most providers use a mix of technologies and service platforms, ongoing infrastructure upgrades are focused on hierarchical integration and interworking strategies that link diverse metro and long haul domains. Important deployment objectives are scalability, resiliency, service consistency, operational efficiencies, and lower cost of ownership. A core challenge is the ability to provision services across multi-technology or multi-vendor network environments.

The ability to provide consistent SLAs throughout the network is a key engineering consideration, as well as a competitive differentiator. Reliability and performance are top Business Ethernet purchase decision factors for many customers, so robust SLAs are clearly a necessity. Business class SLAs offered with current Carrier Ethernet deployments typically provide QoS assurances based on availability, latency, jitter and packet delivery, with more stringent metrics for customer sites that are on-net versus off-net. Other important service features include VLAN support and the ability to assign multiple classes of service (CoS) to prioritize a mix of different traffic types per customer port. Some providers offer additional granularities such as capabilities for QoS per VLAN CoS, or customer management features such SLA reports or network monitoring tools.

Market demand for Long Haul Mesh Ethernet services is a primary driver for recent infrastructure upgrades and new deployments of BGP-based VPLS. These Carrier Ethernet deployments enable the delivery of wide area network services with full mesh Ethernet LAN functionality unbound by metro service geographies.

Figure 1 illustrates a baseline WAN VPLS service from the enterprise perspective. The service offers full mesh interconnectivity for sites located throughout a country or globally. The speeds shown at each site depict the port rate that the customer pays for on a monthly basis. The three sites on the left in the figure are connected to on-net WAN VPLS points of presence using direct fiber. Bandwidth rates delivered at the customer UNI for these sites are 1 Gbps, 100 Mbps and 10 Mbps.

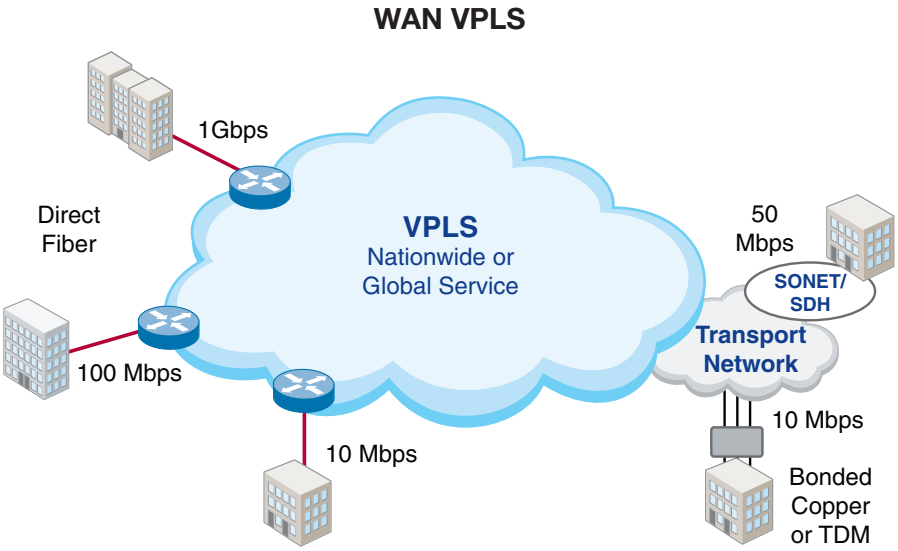


Figure 1

The two customer sites on the right are not located within the provider's direct fiber serving area. Access configurations for delivery of Ethernet UNIs to these sites may utilize SONET/SDH, Bonded Copper or TDM or other solutions. In this example, the customer port rates delivered are 50 Mbps and 10 Mbps. These sites could be served through transport networks owned by the VPLS operator or reached via NNIs (Network-to-Network Interfaces) to other regional, domestic or global service providers. The pending Ethernet NNI (E-NNI) specification is highly anticipated as a standards-based means of extending Ethernet service coverage.

Ethernet providers selectively offer access alternatives to direct fiber to address the scope of their target markets. Implementation decisions are dependent on deployment costs, the complexities of service provisioning, and the ability to deliver uniform service features (e.g., CoS, VLANs, etc.) across all sites. Service pricing strategies are also consequential. For example, how should the direct fiber 10 Mbps VPLS port in Figure 1 be priced relative to the other 10 Mbps port that requires more resources to deliver to the customer?

While the number of domestic and global WAN VPLS offerings is expanding, overall accessibility maps scarcely to the geographic coverage of Frame Relay or IP VPN network services. Until WAN VPLS offerings become more ubiquitous, the use of custom or hybrid long haul mesh Ethernet solutions will continue. Solutions used by providers to meet current requirements include WAN VPLS + Metro LAN, EPL / EVPL + Metro LAN, Hybrid WAN VPLS / IP VPN and the use of E-Access to IP VPNs.

Figure 2 shows a WAN VPLS + Ethernet Metro LAN solution that interconnects two or more “metro islands”. In this scenario, the customer purchases a Metro LAN port for each site plus a WAN VPLS port per Metro LAN. VPLS is used to link the islands together to construct a long haul mesh Ethernet topology. For the customer, this all-Ethernet solution leverages the more extensive availability and lower pricing of Metro LAN services as compared to WAN VPLS. For the provider, provisioning and management may be more complex depending on the infrastructure.

WAN VPLS + Metro LAN

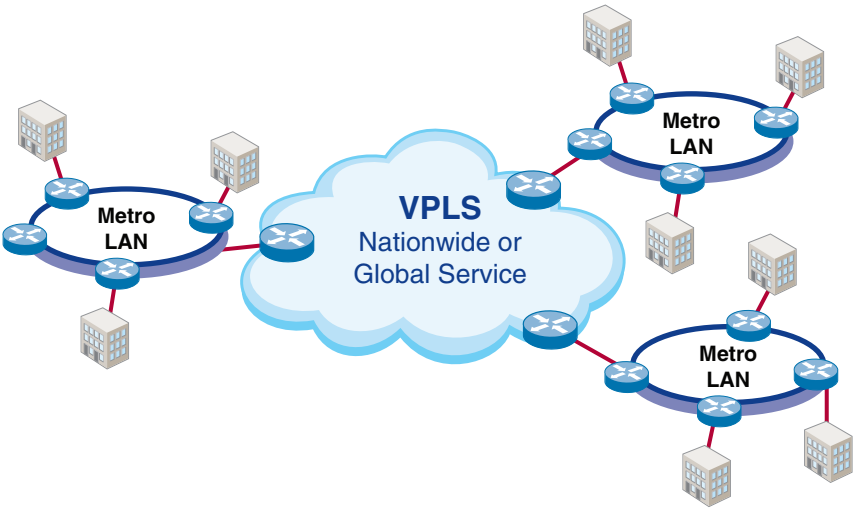


Figure 2

A variation of this scenario is an EPL/EVPL + Metro LAN solution that employs Ethernet Private Lines instead of WAN VPLS to interconnect the metro domains. Because Ethernet Private Lines are priced based on distance, this alternative may not prove in when many long haul connections are required or if the network is extremely geographically dispersed.

Figure 3 illustrates a Hybrid WAN VPLS / IP VPN solution. This long haul mesh option is used for customers with sizeable or more complex networks. For example, high bandwidth Layer 2 WAN VPLS ports are provisioned for large capacity traffic sites, like headquarters or regional data centers. Layer 3 IP VPN service connections are used to reach other geographically remote locations. The customer provides the interworking and controls routing tables for VPLS-connected locations, while routing is handled by the provider for IP VPN-connected sites. In this example, a 100 Mbps E-Access connection is the interface to the IP VPN service.

This solution takes advantage of the greater ubiquity of IP VPN services as compared to VPLS. Providers may offer this type of hybrid solution as a partially or fully managed offering. Some employ CPE-based implementations to establish a demarcation point at each site in order to provide consistent end-to-end SLAs to the customer.

Hybrid VPLS/IP VPN

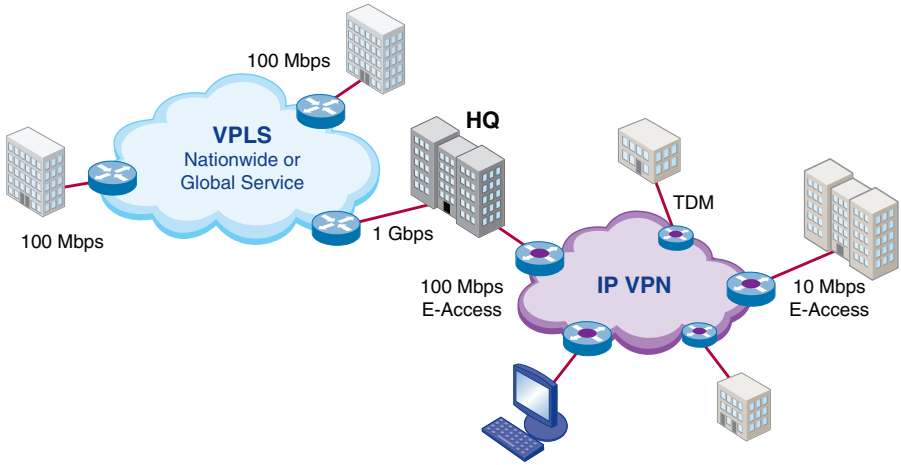


Figure 3

Back to the Future: Ethernet-Enabled Applications

In addition to supporting current customer requirements, Carrier Ethernet infrastructures serve as the underlying transport foundation for enhanced and future applications. “Future-proof” Carrier Ethernet architectures help eliminate the WAN bottlenecks of speed, distance and performance, enabling support for applications that are not efficiently or economically operated over current service architectures.

Macroeconomic conditions and workforce globalization also fuel advanced networking requirements. Customers are under pressure to control IT and network service budgets, while business demands continue to increase for feature-rich networking applications. Costs for processing and storage resources have plummeted, and enterprises anticipate that Business Ethernet services will similarly reduce costs for wide area bandwidth.

Business Ethernet is already being used to efficiently transport high bandwidth applications. For example, film companies transmit multi-terabit movie clips from on-location sites across the world to studios for post-production editing. Healthcare organizations use Ethernet services to share medical imaging applications via picture archiving and communication systems (PACS).

However, there are numerous bandwidth-heavy business applications still limited to metro areas, including data center backup, disaster recovery/business continuity, and SAN (Storage Area Network). Higher performance, wide area Ethernet infrastructures can help remove these geographic boundaries, providing businesses with more flexible network services options. For example, real time mirroring of business-critical information could be performed at greater distances, which would improve application resiliency.

As IT resources are stretched, more business customers are turning to “cloud computing” or network-based application services. The Software-as-a-Service (SaaS) trend is growing for specialized and small business applications, which are widely available on a best effort basis through the public Internet. Broader use of virtual computing services by midsize and large enterprises is dependent on network platforms that deliver high performance, plus guaranteed service quality for users that may be located anywhere in the world.

In addition to bandwidth capacity, switched Ethernet transport also affords lower latency than routed IP services. A key advantage is improved performance for delay-sensitive applications like VoIP, broadcast video or business multimedia. For example, emerging business telepresence services provide live images and audio quality that approach an in-person meeting experience between employees, customers or suppliers. A typical telepresence installation consumes about 15 Mbps of bandwidth per location, and participants may be located in different cities or countries. This application, which needs stringent service quality, requires a network infrastructure that provides for low latency, jitter control, multipoint connectivity and scalable bandwidth. SIP-based (Session Initiation Protocol) applications that support multimedia sessions have similar transport requirements that can be enhanced using an Ethernet service platform.

Carrier Ethernet is also an enabler of applications that require customer control due to industry guidelines or government regulations. Examples include HIPAA, Homeland Security, Sarbanes-Oxley and IRS or SEC filings. As a Layer 2 service, Ethernet enables customers to encrypt their applications for transport over provider networks. Compliance requirements are likely to increase in the future due to government mandates, spurring new Ethernet-enabled applications that necessitate reliable, secure transport of sensitive information.

Carrier Ethernet Deployments: 2010+

To address advanced application requirements, Carrier Ethernet deployments over the next several years will concentrate on enhanced service features, plus Operations, Administration and Maintenance (OAM) improvements. Additionally, new and integrated metro and core infrastructures will be rolled out to support mainstream customer adoption of Business Ethernet services.

OAM enhancements that facilitate application-aware QoS across metros or long haul networks will provide operational benefits and competitive differentiation. For example, advanced automation of provisioning and troubleshooting functions will help providers fine-tune network engineering and service delivery. Capabilities for traffic shaping per port or on a per VLAN basis will be utilized to optimize the use of access and core network bandwidth.

Direct customer benefits of OAM enhancements are improved service experience and reduced application downtime. Stronger SLAs should bolster migration from legacy TDM services to Business Ethernet as customers are assured of predictable application performance, whether the application is real-time data transactions, VoIP or streaming video.

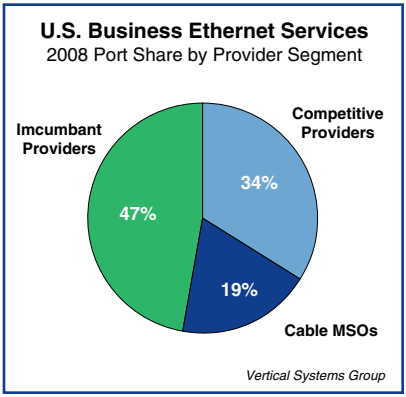
Hands-on network management is a requirement for many enterprises. Customer-oriented tools can provide a range of features such as proactive performance monitoring or detailed SLA reporting. Advanced capabilities may include the ability to purchase bandwidth on-demand like a utility.

Filling the fiber gaps is expected to continue as Ethernet providers further broaden their fiber footprints, as well as offer alternative access options like enhanced copper solutions or wireless. For off-net coverage, E-NNI agreements should add conformity to the inter-provider transport process. Standardization will help lessen current SLA variations between on-net and off-net services.

The convergence of separate provider networks onto a common backbone will drive opportunities for deploying innovative service offerings and for evolving associated business models. To avoid being commoditized, service providers need to evaluate opportunities that monetize or extract maximum value from their networks. For example, Business Ethernet with application awareness could be integrated with services like 3G mobility or IP video to provide a seamless user experience across enterprise, wireless, and residential domains.

Service Provider Landscape – Who's Delivering Business Ethernet?

Business Ethernet services are available from hundreds of providers worldwide, including more than sixty companies offering services in the U.S. market. The U.S. Ethernet landscape has three distinct provider segments: Incumbent Carriers, Competitive Providers and Cable MSOs. Differentiators among these segments are market focus, scope of the installed base, geographic service reach, and the portfolio of Ethernet services offered.



Incumbents are the primary providers of retail Business Ethernet services in the U.S., supplying 47% of the 2008 customer port base. Ethernet providers in this segment include AT&T, Embarq, Qwest and Verizon. Incumbents have sizeable embedded customer bases, broad regional or nationwide service coverage, and extensive fiber and SONET facilities. Through a string of major company mergers, Incumbents have undergone rapid transformations in the last several years, resulting in a mix of diverse service technology platforms, and varied service offerings. Capital expenditures to support legacy services like Frame Relay have been capped, while spending has increased for fiber build outs and network integration. Network infrastructure goals are to reduce operating costs, streamline operations, and position for advanced services.

Competitive providers encompass regional, global and specialized carriers that operate fiber-based networks or utilize third-party network facilities. Providers in this segment offering Business Ethernet services in the U.S. include AboveNet, Cogent, Expedient, Global Crossing, Level 3, Masergy, Orange Business, Reliance Globalcom, tw telecom, Veroxity and XO. This segment accounted for 34% of 2008 Business Ethernet ports. Competitive providers focus on medium to large business customers within a geographic (e.g., metro, global, etc.) or niche market (e.g., vertical industry, business application, etc.). Most Competitive providers have little or no embedded base of legacy services to protect, so Business Ethernet offerings are positioned to attract customers migrating their networks from other providers' services. Without legacy platforms to maintain, Competitive providers can more readily deploy new technologies and services in response to customer demand.

The business-oriented entities within **Cable MSOs** are also providers of Business Ethernet services to U.S. customers, accounting for 19% of installed ports. These entities, which are operated separately from residential cable operations, include Charter Business, Comcast, Cox Business, Optimum Lightpath, RCN, SuddenLink and Time Warner Cable. Cable MSOs have dense on-net service availability via fiber and HFC (hybrid fiber coaxial) within their respective service regions. Target customers are small and medium businesses, state and local government, education and healthcare entities. Basic DIA and Metro LAN services are the primary Business Ethernet services offered by Cable MSOs. Service infrastructure upgrades are focused on OAM enhancements, expansion of fiber footprints, and support of new service features.

The next sections contain profiles that describe how and why two Business Ethernet providers, AT&T and Reliance Globalcom, are deploying global BGP-based VPLS Carrier Ethernet solutions. Additionally, the profiles summarize the evolution of these infrastructures in support of business-class services for U.S. and multinational enterprises.

Profile: AT&T

AT&T is a leading provider of business network services to U.S.-based customers with regional, nationwide or multinational requirements. The company was formed through SBC's acquisition of the former AT&T in 2005 and the subsequent merger with BellSouth in 2006.

AT&T is actively deploying BGP-VPLS as an overlay to its existing MPLS network. This architecture ultimately enables AT&T to migrate all of its services onto a common backbone infrastructure. Network integration provides a number of operational benefits for AT&T, including simplified administration and the capabilities to provide uniform service levels. According to Bob Walters, Executive Director of Ethernet Product Management, "AT&T's global VPLS architecture brings scalability, efficiency, and operational consistency to our delivery of business-class services."

> ***"AT&T's global VPLS architecture brings scalability, efficiency, and operational consistency to our delivery of business-class services."***
>
> **Bob Walters**,
> AT&T, Executive Director of Ethernet Product Management

The core VPLS platform is designed to support and integrate multiple Business Ethernet services currently offered by AT&T, including long haul OPT-E-WAN® and metro OPT-E-MAN® and Metro-E services. AT&T's goal is to provide consistent, ubiquitous on-net access to its Ethernet offerings at speeds from 2 Mbps to 10 Gbps. The existing metro infrastructures are being interworked with the new core architecture through Ethernet gateways. AT&T's on-net Ethernet service coverage extends to thirty-five hundred U.S. central offices, plus thirty-six countries. Service availability is broadened through Mid-band (Ethernet over copper) and Ethernet over TDM access options. The company also maintains NNI agreements with numerous U.S. and global providers.

Access ubiquity and service integration are important to the migration of AT&T's substantial Frame Relay/ATM customer base. Opt-E-WAN is positioned as a high performance Layer 2 migration solution for customers who want to maintain control of their own networks. Many Frame Relay customers have already made the transition to IP VPN, AT&T's managed Layer 3 offering. For large, meshed topologies, AT&T offers solutions that connect customer sites to either IP VPN services or native Ethernet services, dependent upon service availability and connectivity requirements. AT&T currently offers four service classes for Ethernet, and six for its IP VPN service. When the common Ethernet infrastructure is fully implemented, a benefit for customers will be seamless end-to-end connectivity among all of their networked sites, regardless of whether they choose Layer 2 or Layer 3 services.

AT&T's Carrier Ethernet infrastructure is also being utilized to transport the rising volume of mobile wireless traffic, as well as to expand Ethernet coverage to more cell sites. Additionally, it is the underlying architecture supporting advanced AT&T business solutions like Telepresence, and is designed with the scalability to accommodate future traffic growth.

The need for automated operations and management tools is expected to increase as AT&T integrates its networks. One of the most challenging functions is traffic engineering to optimize customer networks based on specific applications and traffic characteristics.

The company believes that standards are important, and relies on the MEF as the benchmark for certifying that vendor equipment is carrier grade. Certification also extends to AT&T's Ethernet services, which are compliant with MEF 9 and 14 specifications.

AT&T offers a portfolio of business IP, Internet, wireless and voice services for U.S.-based enterprises with metro, nationwide or global networking requirements. The company also offers residential Internet, voice and TV entertainment services in the U.S.

Business Ethernet Market Focus

Customer Profile: Medium and Large U.S. Businesses, U.S.-based Multinational Enterprises

Services Offered: DIA, Metro Private Line, Metro LAN, WAN Private Line, WAN VPLS, WAN VPNs

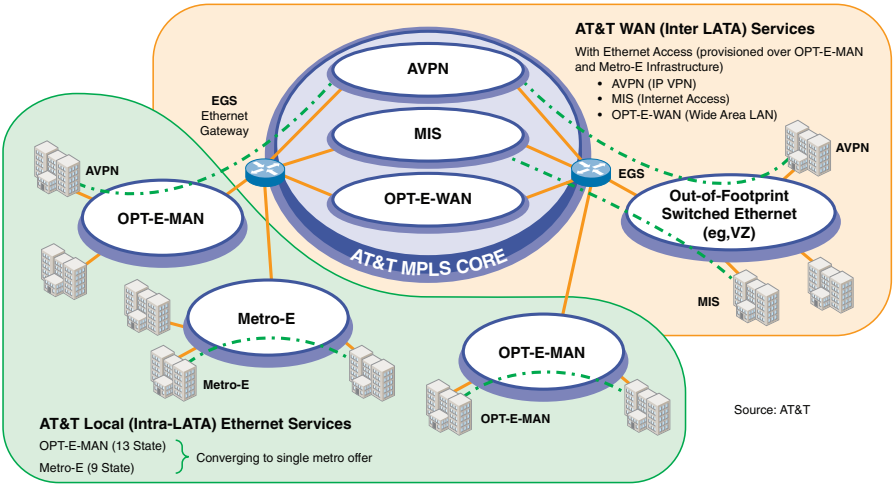
Access Speeds: 2 Mbps to 10 Gbps

Service Coverage:
- 228 POPs and 3,500 COs equipped for Ethernet service in the U.S.
- 36 countries

Top Advantages:
- Broad range of Ethernet service capabilities
- Service compliance with MEF (Metro Ethernet Forum) 9 and 14 specifications

AT&T Ethernet

Shared Infrastructure Used for Multiple Services



Source: AT&T

Carrier Ethernet Evolution for AT&T

- Converge all existing metro infrastructures to a common Ethernet architecture built on core MPLS network
- Expand AT&T's on-net Ethernet service availability in the U.S.
- Continue investment to expand features, capabilities and improve customer experience
- Increase AT&T's global fiber footprint
- Continued expansion of 10 Gbps capabilities
- Continue to expand fiber and copper coverage to wireless cell sites
- Expand Mid-band Ethernet footprint and Ethernet over TDM solutions

Profile: Reliance Globalcom

Reliance Globalcom is a global provider of fully-managed network and communications services for medium to large businesses, multinational enterprises and carriers. Reliance Globalcom is the global operations division of Reliance Communications and combines the former Yipes, an Ethernet services company, Vanco Group, a virtual network operator, and FLAG Telecom, the operator of an extensive undersea cable system. The company offers services in more than two hundred countries and territories across six continents.

The global backbone of the Reliance Globalcom network is a BGP-VPLS over MPLS platform. The company recently extended its core VPLS network throughout all of its metro networks, with the goal of a uniform, seamless infrastructure.

> *"Seamless integration of Layer 2 and Layer 3 services provides flexibility in configuring an optimal solution for each Reliance Globalcom customer."*
>
> **Dr. Shankar Narayanaswamy,**
> Reliance Globalcom,
> VP Network Architecture

Reliance Globalcom's top drivers for choosing this architecture are scalability, high performance and the functionality to provide both Ethernet and IP VPN services throughout the network. Additional benefits are ease in service provisioning and management, which are vital components in the company's delivery of customer networks that may span multiple continents or include multiple services. "Seamless integration of Layer 2 and Layer 3 services provides flexibility in configuring an optimal solution for each Reliance Globalcom customer," according to Dr. Shankar Narayanaswamy, Vice President of Network Architecture.

Reliance Globalcom offers managed Layer 2, Layer 3 and hybrid solutions. Service availability for its new Enterprise Global Ethernet service covers seventeen countries. The Enterprise Global Ethernet service includes Metro and WAN point-to-point and VLPS services. Customer access speeds for Ethernet services range from 1 Mbps through 1 Gbps, in granular increments of 1 Mbps.

Service management includes equipment provisioning and maintenance, real-time performance monitoring and troubleshooting. Business-class SLAs are standard per network site. A web-based customer portal provides access to account information, management reports, SLA metrics and performance tracking information.

Reliance Globalcom supports long haul mesh customer topologies utilizing Ethernet, IP VPN, MPLS or a hybrid solution. Service choices are based on network and application considerations, but also consider the customer's technical resources. Reliance Globalcom works with the customer's technical staff to choose and design the most suitable solution.

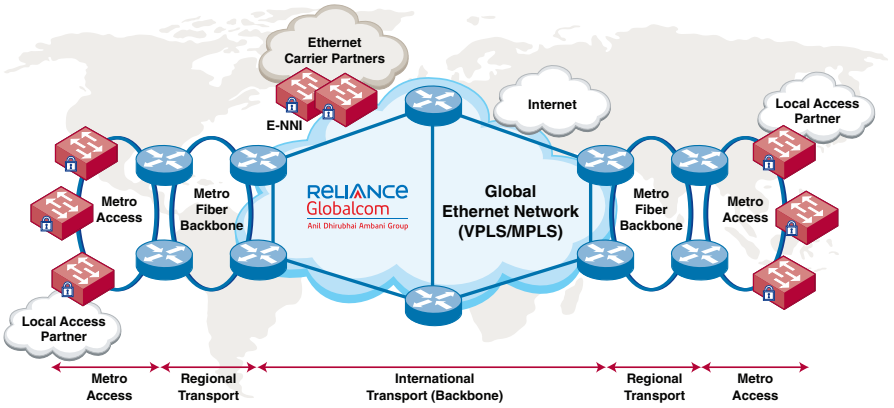
Geographic service expansion is on Reliance Globalcom's priority list. The company has twenty-one Ethernet NNIs already in place, and expects to add more based on customer requirements. T3 and other TDM access alternatives are used where necessary to cover off-net locations, both in the U.S. and in selected countries. Reliance Globalcom has established business relationships with hundreds of carriers to extend its service reach worldwide. Another high priority is the implementation of enhanced OAM features, including further automation of service provisioning and troubleshooting functions.

Reliance Globalcom
Anil Dhirubhai Ambani Group

Reliance Globalcom provides managed network and communication services in 230 countries and territories across six continents. The company's Data Business serves global multinational, large to midsize enterprise, and carrier markets.

Business Ethernet Market Focus

Customer Profile:	Medium and Large Global Businesses, Multinational Enterprises
Services Offered:	Managed Metro Ethernet, Ethernet VPLS, Ethernet Private Line
Access Speeds:	Network speeds ranging from 1 Mbps to 1 Gbps in 1 Mbps increments
Service Coverage:	• Ethernet VPLS coverage to 17 countries • Managed Ethernet services using any access - e.g., fiber, copper (T1, DS3), etc.
Top Advantages:	• Global solution for entry to emerging markets • Service assurance with business-class, premise-to premise SLAs



Source: Reliance Globalcom

Carrier Ethernet Evolution for Reliance Globalcom

- Extend existing Ethernet VPLS global service platform
- Extend the MPLS/VPLS paradigm from the global core into the metro backbone networks
- Increase Reliance Globalcom's global fiber footprint
- Implement enhanced features for Ethernet service provisioning and management
- 21 strategic Ethernet NNIs with global carriers; continue to identify and evaluate other NNIs

Get Ready for the Evolution

The evolution to ubiquitous Business Ethernet service connectivity is underway. For enterprise customers, major benefits are the elimination of today's WAN bottlenecks and significant performance improvements for advanced applications.

Expansion of the rapidly growing Business Ethernet market will be driven by service availability, affordability and ease of service migration. Navigating this evolution requires a flexible service infrastructure that not only supports today's customer needs, but is also adaptable to future requirements.

Leading service providers are implementing Carrier Ethernet solutions to integrate their service platforms, increase network capacity, simplify operations and bring consistency to service delivery. Near-term initiatives focus on upgrading metro and core infrastructures, expanding service coverage, and rolling out WAN VPLS services. During the next several years, provider deployments of advanced service capabilities plus OAM enhancements will further foster the goal of seamless wide area Ethernet transport.

About Vertical Systems Group

Vertical Systems Group is recognized worldwide as a leading market research and strategic consulting firm specializing in defensible quantification of the networking industry. Market information referenced in this report is derived from Vertical Systems Group's ENS (Emerging Networks Service) research service. ENS is a comprehensive resource for analysis of broadband services markets, including Business Ethernet, IP VPNs, Frame Relay, ATM, Private Lines, Access, Broadband Internet, Fiber and more.

For more information: **www.verticalsystems.com**

About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses.

Additional information can be found at **www.juniper.net**.

Juniper® NETWORKS

Document sponsored by Juniper Networks

Vertical
Systems
Group

7100102-001-EN