NEC Eluminant Technologies, Inc.
White Paper

Passive Optical Networking for Small and Medium-Sized Enterprises

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Rising Bandwidth Demands of Small and Medium-Sized Enterprises Raise Requirements for Network Access Speeds

Introduction

Businesses of all sizes are adopting new services and increasing their use of traditional voice and data services as they seek to make their businesses as productive as possible. The explosion of new data and voice services is resulting in ever-increasing demands for greater broadband bandwidth from the providers of telecommunications services. Among the many applications driving demand:

- Connectivity for high-speed LANs, such as 100BaseT
- High-speed Internet access
- E-commerce
- Full-screen and full-motion videoconferencing
- Video on demand
- Telemedicine
- Access to vast electronic libraries
- Outsourced IT applications and application hosting
- Voice over Internet Protocol (VoIP) and other voice over data protocols, such as voice over ATM (VoATM) and voice over frame relay (VoFR).

Bandwidth demand just for data and IP traffic is growing dramatically. A survey of major corporations by telecommunications research firm, the Yankee Group, Boston, found that 40 percent of respondents said their data and IP traffic would grow by more than 25 percent in 2001. Also, 2000 was seen as the voice-data transition year, as carriers reported data traffic exceeding voice traffic for the first time.

Services such as application hosting, which today are in their infancy, are likely to be mainstream in five years, and become ubiquitous in 10 years. This underscores the imperative that not only must businesses and their service providers plan for the near-

term demand of the next 12-18 months, they also must be prepared for the likely demands of the next five to 10 years.

For example, application hosting and Application Service Provider (ASP)-delivered IT services require a minimum of 128 kbps per desktop or user, according to telecommunications research firm, Phillips InfoTech, Parsippany, NJ. If, as many expect, ASP-delivered software applications become commonplace over the next 10 years, a 100-person enterprise could be looking at a minimum bandwidth requirement of 2,000-4,000 kbps to support just this requirement. But as applications include more graphics or video, the requirement could rise to 300 kbps per user.

The burgeoning number of new businesses conducting e-commerce — or even delivering their product (e.g., computer gaming services) electronically — also require high-bandwidth connections to the Public Switched Telecommunications Network (PSTN).

There are a huge number of such potential bandwidth-hungry smaller businesses. While carriers' attention often is focused on the largest enterprises, small and medium-sized enterprises, or SMEs, comprise a sizable universe and represent a huge pool of bandwidth demand. There are perhaps 6.5 million small companies (50 or fewer employees) in the U.S. Of medium-sized firms, having from 51 to 500 employees, there are approximately 610,000. There are only 16,000 large enterprises with more than 500 employees. According to Ronald Kline, a senior analyst at telecommunications industry firm Ryan, Hankin, Kent Inc., South San Francisco, CA, these small and medium-sized organizations need high-bandwidth service to be able to deploy applications such as 10/100 ethernet and giga ethernet networks. And they need to do this without rebuilding their premise network infrastructure or working with a service provider to deploy a private network.

> *"Typically, small- and medium-sized businesses can't afford to build private networks and must rely on service provided by ILECs, CLECs, ISPs, and ASPs," says Ronald Kline, senior analyst at Ryan, Hankin, Kent, Inc. "Service providers will invest in optical edge devices that can provide [high-speed] services in a cost- effective manner. The idea is to reduce the cost per bit."*

The bandwidth demands of SMEs and larger businesses already are taxing the limits of existing copper infrastructure. In the short-term, many smaller businesses are coming to rely on Digital Subscriber Line (DSL) links, which provide for relatively high-speed Internet connections over copper lines. Very high data rate digital subscriber line (VDSL), just beginning to be deployed, delivers up to 52 Mbps of bandwidth over copper wire.

In addition to DSL, another way that carriers are serving these new bandwidth requirements is by placing ATM Customer Premises Equipment (CPE) in individual business locations. This allows provisioning services such as managed ATM and managed frame relay for voice, video and data services. These devices are linked to carrier networks via OC-3 or DS-3 connections.

However, while DSL is generally regarded as suitable for many of today's business applications (i.e., video streaming and e-commerce), it is unable to guarantee high quality of service (QoS) at an affordable price for applications with both high upstream and downstream requirements (e.g., video conferencing, interactive gaming, etc.). Unlike DSL, optical facilities are capable of delivering fully symmetrical bandwidth rates. Thus, fiber-optic technologies such as passive optical networking (PON) represent an ideal media for a wide variety of converged applications; basically, PON can offer the same services and even higher bandwidths than DSL, without the range limitations of DSL.

Fiber Deployment Moving Closer to Subscriber

The long-term solution for telecommunications carriers and Internet service providers alike is signal transmission over fiber-optic networks. According to a 1998 market research report by Technology Futures, Inc., Austin, Texas, 99 percent of all interoffice connections are expected to use fiber by 2000, and 99 percent of all customer access lines will likely use a fiber feeder by 2015.

Some carriers already are deploying fiber access solutions for small and medium-sized businesses. One example is FiberNet. This New York-based firm is a carriers' carrier that provides fiber-optic infrastructure to commercial buildings, connecting the building to long-haul fiber-optic networks via links to carrier central offices and multi-carrier "telehotels." Trey Farmer, FiberNet's chief operating officer, says that installation of fiber in multi-tenant buildings allows running multiple data and voice transmission technologies on a single network.

But most businesses are not able to get the kind of fiber access that FiberNet is offering. Fiber has been extensively deployed by telcos since the 1970s, and fiber links pass by the majority of U.S. businesses. As of 1999, 76 percent of all U.S. businesses were located within a mile of an available source of fiber — but less than 5 percent had access to it, according to a report by Vertical Systems Group, Inc., Dedham, MA. This dilemma is particularly true for SMEs.

While deploying fiber in network backbones clearly has proven cost-effective, the cost of installing fiber links directly to small and medium-sized businesses and residential customers has, until recently, been relatively high. One fiber solution that is lower-cost for this "last mile" connection is the passive optical network.

The PON Alternative

PON technology, which lets carriers serve customers quickly without adding miles of new fiber, is particularly attractive as a broadband solution for small and medium-sized enterprises, as well as residential subscribers.

PON emerged from the Full Service Access Network (FSAN) effort, a global initiative involving more than 20 of the largest telcos in Asia, Europe and North America. Through FSAN, an International Telecommunications Union (ITU) Passive Optical Networking specification (G.983) emerged.

The PON specification allows new and incumbent carriers to offer DS1 service with easy migration to higher-speed access as a customer's bandwidth needs increase. According to the Yankee Group, with PON, carriers today can offer more than 10 Mbps access at a price that is competitive with tariffed T1 (1.54 Mbps) service.

As the cost of fiber technology continues to drop, PON will become even more competitive.

With ATM-based PON, no active electronics are required between the Optical Line Terminal (OLT) located at the Central Office (CO) and the associated Optical Network Terminals (ONTs) located on the customer premises. The OLT can have multiple PON units, each of which drives an optical distribution network (ODN)—through inexpensive passive optical splitters—to connect up to 32 ONTs. WDM is used in the ODN for simultaneous downstream and upstream traffic. The downstream traffic from the OLT to the ONTs is based on broadcasting a stream of ATM cells. An ONT picks up its own downstream traffic by matching the cells' addresses to its own address. The upstream

traffic from the ONTs to the OLT is based on a TDMA protocol. This protocol is necessary to avoid collisions of upstream traffic from multiple ONTs to the OLT. To control upstream traffic, the OLT issues "grants" to specific ONTs for them to send traffic upstream in the assigned time slots. This allows for dynamic bandwidth assignments for traffic connections through the PON system and ensures that the required quality-of-service (QoS) is met.

The PON system is designed to provide both packet- and circuit-based services efficiently for ATM, TDM, PSTN and IP traffic. With the passive optical distribution networks, there is no need for active loop electronics and monitoring equipment in the access network. This is obviously a great cost saving over the current point-to-point architecture.

The PON links terminate on the customer premises at an ONT that has interfaces for 10/100 ethernet and DS1 for ATM, frame relay and traditional voice (including dial-up data/video) services. In the near future, ONTs are expected to include DSL capability. This will be important to permit servicing the existing base of DSL subscribers. It also will be important for fiber-to-the-curb residential applications, for which DSL services may have a longer market life than is true of the business marketplace.

From a total cost of ownership perspective, PON is much less expensive than the widely deployed SONET (synchronous optical network) technology. Managing a SONET ring is a time- and labor-intensive proposition, and it is costly to upgrade. PON allows multiple fiber connections to be provisioned from a single connection, and these are upgradable by simply loading a new configuration.

The 9-12 mile range of PON links also can satisfy the distance required for most SME links to reach a fiber-optic backbone.

Commercial Solutions Nearing Market

PON equipment vendors are working with carriers to provide fiber-based services to businesses today. Most PON vendors will have commercial solutions on the market in 2001. Most near-term PON deployment will involve new buildings or rehabilitated office buildings.

The Yankee Group anticipates the market for PON and direct wavelength access hardware to top $910M and $1.4B, respectively, by 2004. Communications Industry Researchers Inc., (CIR), Charlottesville, VA, expects PON connections to businesses to grow rapidly: 125 percent between 2000 and 2001 and by about 300 percent by 2004.

> *Yankee also sees PON as enhancing existing digital services. "PON vendors and ILECs will offer DS1 services including voice, along with 10-100 Mbps Internet access, on a scalable fiber-based platform," says Alex Benik, an analyst in the firm's San Francisco office. "Given that there are over 1 million such DS1s deployed today by incumbents, not to mention IXCs and CLECs, this is a large target market."*

Prices for fiber optics have been steadily dropping and industry standardization efforts will ensure this trend continues. Other market factors include the request to the Federal Communications Commission by the Association for Local Telecommunications Services (ALTS) to require ILECs to lease access to their remote terminals to CLECs and other alternative carriers. The FCC already has ordered that ILECs must make extra optical fiber available to competitive carriers.

According to FiberNet's Farmer, metropolitan areas present the most significant challenge to the delivery of broadband services, and may represent an opportunity for deployment of PON. Farmer points out that PON has an advantage in this environment, as it can be deployed without use of active devices, whose deployment raises power grounding and other potential problems. He notes that PON also can be deployed faster than active fiber-optic technology.

The continued deployment of DSL also may in turn spur deployment of PON links. As carriers move to deploy DSL services, they often are replacing copper-based, repeated T1 links with fiber links. Though driven by the need to tap today's DSL market, these new links also make it easier to deploy a PON solution at some point.

Demand, ultimately, will determine where PON is installed.

> *"While I'm a big believer that bandwidth needs are growing exponentially, they aren't expanding at the same rate everywhere. For the high end, large city, big business accounts, we're seeing an incredible boom in bandwidth, an incredible appetite for technologies because it's performance driven," says FiberNet's Farmer. "This is where PON makes sense to me."*

Summary/Conclusion

In the end, carriers and service providers all will take steps to deploy last-mile infrastructure that will meet the growing bandwidth demands of customers. As they look at their own networks, they will be able to determine whether PON, VDSL or other options, such as LMDS or giga ethernet, represent the solution that offers the best blend of meeting current and future requirements, network compatibility and cost. Most likely,

carriers will find that some mix of these options is the best choice. For example, PON and VDSL might be used together in a fiber-to-the-curb deployment. PON even can work in conjunction with emerging wireless technology. A report by the Yankee Group asserts that a wireless link can bring OC-3 services into a large building, where PON then can serve to distribute high-bandwidth services to individual businesses in the building.

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BANDWIDTH REQUIREMENTS FOR SERVICES

Service	Required Bandwidth
Collaborative remote studio, video editing	45 Mbps
Full-motion videoconferencing or streaming	6 Mbps (MPEG)
Lower-quality videoconferencing	128 to 384 Kbps
Application hosting/delivery	128 Kbps per desktop or user
HDTV	18 Mbps
Telemedicine	1 Mbps
Remote learning, online university	56 Kbps
Business inventory and remote store management	128 to 256 Kbps (bursty)
Electronic investment and banking	56 Kbps

BANDWIDTH AND DISTANCE CONSIDERATIONS

Network Service	Distance Limit for Bandwidth Ranges
PON	Max. of 9-12 miles for 155 Mbps symmetrical
Asymmetric VDSL	Max. of 1,000 ft. for up to 51.84 Mbps for downstream
	Max. of 3,000 ft. for 12.96 to 25.92 Mbps for downstream
	Max. of 4,500 ft. for 6.48 to 12.96 Mbps for downstream
	Max. of 1,000 ft. for 3.24 to 6.48 Mbps for upstream
	Max of 3,000 ft. for 1.62 to 3.24 Mbps for upstream
	Max. of 4,500 ft. for 1.62 to 3.24 for upstream
Symmetric VDSL	Max. of 1,000 ft. for 19.44 to 25.92 Mbps
	Max. of 3,000 ft. for 6.48 to 12.96 Mbps

Bandwidth Demand and PON Resource Guide

Association for Local Telecommunications Services, www.alts.org

Federal Communications Commission, www.fcc.gov

International Telecommunications Union, www.itu.int/

Ryan, Hankin, Kent Inc., South San Francisco, Calif., www.rhk.com

Technology Futures, Inc., Austin, Texas, www.tfi.com

United States Telecom Association, www.usta.org

Vertical Systems Group, Inc., Dedham, Mass., www.verticalsystems.com

Yankee Group, Boston, Mass., yankeegroup.com

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