Telecom Carriers Actively Pursue Passive Optical Networks

George Lawton

As optical networking has become more affordable, it has moved from the network backbone to wide and metropolitan area networks and then to the local loop. To take advantage of this, telecommunications providers have begun experimenting with various fiber-based technologies to find ones that offer high performance at low cost. One of the leading candidates has been touted for years as the wave of the future: passive optical networks.

PONs—considered "passive" because the network infrastructure between the carrier backbone and the customer includes no active electronic elements—enable the deployment of relatively inexpensive, high-bandwidth, point-to-multipoint, voice, video, and data networks either to or near customer premises. These networks could be used for Internet access, metropolitan area networks, or corporate LANs.

A PON could serve as a first-mile technology for connections between carriers and users. In the short run, proponents foresee PONs competing favorably with cable-modem and DSL-based broadband networks, which also carry voice, video, and data.

The three main PON flavors are based on asynchronous transfer mode (ATM), Ethernet, and the Gigabit PON Encapsulation Method (GEM).

Japan has been leading the way with significant Ethernet-based deployments, while US carriers, in their early PON adoption, are focused on ATM.

US companies such as BellSouth, Southwestern Bell, and Verizon; Asian providers such as Japan's NTT; and European carriers such as British Telecom are deploying PONs. However, the technology faces significant challenges to widespread access, such as the cost of deploying the networks and uncertainty about how the market will evolve.

DRIVING DEMAND FOR PON TECHNOLOGY

British Telecom made the initial PON trial deployments in the late 1980s. Raynet began selling a PON-based system in 1989, but the technology lost traction as carriers moved to higher-performance, active, single-mode fiber approaches, according to Paul Shumate, a PON pioneer and now executive director of the IEEE Lasers and Electro-Optics Society (LEOS).

Fiber-optic networks have since become easier to install. In addition, optics' cost has dropped, making the technology, formerly practical only for telecommunications carriers' backbones, more feasible for deployment to consumers and companies, said Ed Szurkowski, director of Lucent Technologies' Optical Data Networks Research Department.

For these price-sensitive markets, lower-cost PONs make more sense than traditional active optical networks. And PONs promise much more bandwidth than DSL or cable-modem technology.

The higher bandwidth would be particularly useful to established telecommunications providers, who want the new revenue that fast video and data services could generate. These providers are losing voice-related business to cell phones and Internet telephony, said Gary Lee, chair of the PON Forum and president and CEO of FlexLight Networks.

However, providers want to offer their customers attractively priced services, and PONs, by eliminating active electronic components, are less expensive than other optical technologies.

PONs are also more reliable because they don't depend on intervening electronics that could fail, and they are easier to upgrade because there are no active electronics to replace.

Additionally, regulatory factors are making PONs more attractive investments for telecommunications carriers. The US Federal Communications Commission recently eliminated requirements that let smaller, newer, competing carriers inexpensively use the optical networks that established regional companies build.

This has given the regional companies more incentive to invest in fiber, explained Denise Koenig, a spokesperson for telecommunications carrier SBC.

International regulations are going even further, noted Craig Easley, chair of the Ethernet in the First Mile Alliance (EFMA), which supports and helps market Ethernet PONs and other Ethernet-based first-mile technologies, including those using active-optical- and copper-based approaches. In Japan and some parts of Europe, he explained, governments offer carriers tax credits covering the cost of building new fiber networks.

HOW PONS WORK

The key to PONs is their ability to transmit signals over fiber without using active electronic components.

Active optical networks contain electronic components such as regenerators—which convert signals from optical to electronic and then back to optical—and routers. PONs, on the other hand, use only optical components.

A PON consists of an optical line termination, a central distribution transceiver at the service provider's local facilities that serves multiple optical network units. ONUs are transceivers at the user's home or office. Both OLTs and ONUs convert binary data streams into an optical format that laser beams can carry.

When OLTs send a signal to an ONU, the latter converts it into separate video, voice, and data streams. This means the PON doesn't need the intelligence to do so, which reduces network complexity.

OLTs and ONUs can contain components such as analog-digital processors, fiber-optic ports to connect to a PON system, electronic ports to plug into an Ethernet adapter for accessing data from Ethernet systems, software for managing the flow of traffic between the PON system and other networks, and chipsets with lasers for transmitting optical signals.

Because multiple ONUs share a single OLT port and optical feeder, the PON system needs a sophisticated time division multiplexing (TDM) algorithm to separate multiple signals on the same fiber so that they don't interfere with one another. This eliminates the traffic collisions that would cause many applications to fail.

PONs use a splitter to divide a single optical signal into several signals identical to the original. The system then passes the signals down fibers to or near individual user premises. Because each node receives the entire original signal, the system uses encryption to enable a node to decode only the part it is supposed to receive. Each node uses its own laser to transmit signals upstream.

Some PONs can be configured to change bandwidth allocations to individual ONUs on the fly, depending on users' needs. This can enable carriers to more fully utilize their systems and also provide bigger users with more bandwidth, a potentially revenue-generating service.

As fiber becomes more prevalent, PONs become more popular.

PON TYPES

There are two ways to distinguish PONs: how close they are deployed to customers and the protocol they use to carry data.

FTTN versus FTTP

Some telecommunications carriers, such as BellSouth and SBC, are running fiber to the neighborhood (FTTN), to a box near homes or offices, and then over existing high-speed copper wiring to individual premises. Other providers, such as Verizon, are establishing fiber to the premises (FTTP), particularly for new homes or offices that don't already have copper-wire connections.

Building fiber all the way to premises is more expensive than building fiber to a neighborhood. However, because FTTP networks use only fiber, which lasts longer than copper wiring, they promise more long-term reliability and savings, noted analyst Richard Mack of KMI Research, an optical-networking consultancy.

PON protocols

The PON provides the physical layer for transmitting the signals. To carry the data, the systems use technologies such as ATM or Ethernet, which offer various advantages in data-transfer efficiency, redundancy, quality of service, complexity, and cost.

ATM and broadband PONs. APONs were the first ATM-based PONs and provide voice and data, but not video, services. They offer speeds of 155 to 622 Mbits per second downstream and 155 Mbps upstream, and support 16 or 32 nodes and dynamic upstream bandwidth allocation. APON deployment is phasing out as carriers move to broadband PON systems, which can handle video.

BPON technology is an APON extension that moved the wavelength for sending data and audio from 1,550 to 1,490 nanometers, thereby opening up the 1,550-nm band for video, explained Dave Cleary, vice president of advanced technology at Optical Solutions, a PON equipment manufacturer.

Transceiver improvements have provided the increased power and sensitivity required for handling video without significant added cost.

Michael Howard, an analyst with Infonetics Research, estimated that 75 percent of PON systems in the US, where most telecommunications carriers already use ATM, are BPON based.

Ethernet PONs. EPONs support data rates of 1.244 Gbps in each direction shared among 16 to 256 nodes. The EFMA's Easley predicted next-generation EPON equipment will support data rates up to 10 Gbps. EPONs are based on the IEEE 802.3ah—Ethernet in the First Mile—standard.

The main attraction of Ethernet in PONs is that most companies already use the technology in their corporate networks, said Easley.

Howard estimated that 75 percent of PON systems in Asia, where most telecommunications carriers don't use ATM, are Ethernet based.

Gigabit PON. GPON supports data rates of 622 Mbps to 2.488 Gbps downstream and up to 2.488 Gbps upstream, shared by 16 to 128 nodes. The higher speeds enable carriers to split the bandwidth to serve a greater number of nodes than APONs or BPONs.

According to Howard, industry observers see GPON as the successor to BPON because it is faster and flexible, supporting ATM, Ethernet, and TDM on the same network.

With GPON, all services are mapped onto the PON using either ATM or GEM, a variant of Sonet's (synchronous optical network's) generic framing procedure. GEM lets a GPON link carry both Ethernet and TDM traffic and also adds QoS and recovery capabilities.

Carriers are deploying GPONs throughout the world. Two major GPON equipment manufacturers are FlexLight and Optical Solutions.

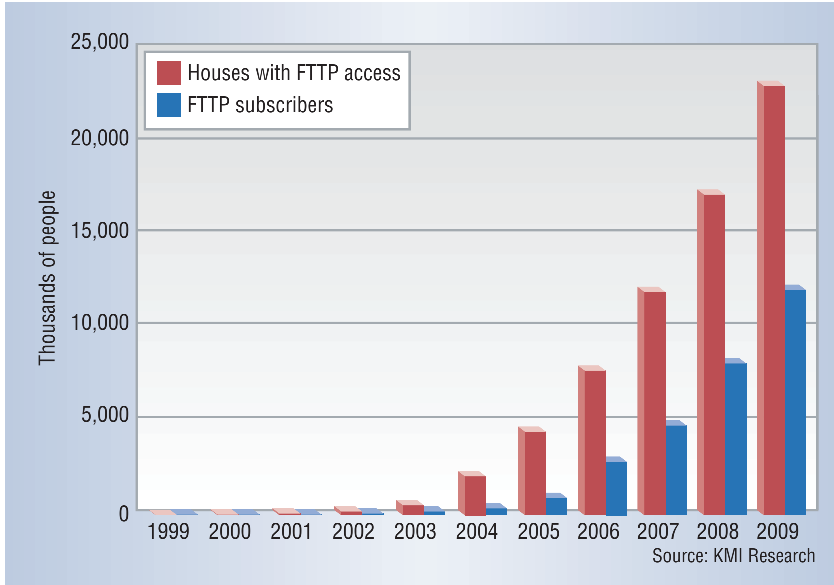

Figure 1. KMI Research, a market analysis firm, projects that the number of US homes deploying fiber-to-the-premises networks and the number of homes with FTTP access will grow dramatically during the next few years.

PONS' CONS

The major challenge to PON adoption, particularly for carriers using copper-based networks, is the significant labor- and engineering-related deployment costs, according to the IEEE LEOS' Shumate.

He said these costs have become a more significant adoption barrier in recent years, as competition from broadband providers has made telecommunications carriers want to recover their deployment costs more quickly than in the past.

Better integration of components and other manufacturing advances in PON chipsets have reduced costs by making lasers and analog-digital processors less expensive per unit of bandwidth.

Vendors are working on integrating all PON-transceiver components into single chipsets, which would significantly reduce systems' size and cost, noted Armando Pereira, vice president of the Optical Business Unit at Centillium Communications, a provider of broadband network access products that has already developed an integrated PON chipset.

Carriers will face a challenge in learning the most efficient and cost-effective way to phase out their old copper networks and phase in PONs, added Lucent's Szurkowski.

Provisioning network services will pose another hurdle for PONs, according to Pereira. He said asymmetric DSL's success has been largely due to customers' ability to install their own modems when they subscribe for service. Provisioning fiber-based services, on the other hand, involves different tools and more sophisticated skills than connecting copper wires.

Analysts are expecting strong growth for fiber deployments. Infonetics' Howard said that as the cost of fiber continues to drop and gets close to that of copper, it will make sense to switch to optics. "In 20 to 30 years," he said, "everything will go to fiber."

KMI projects the number of US homes with access to FTTP-based networks will climb from 2 million in 2004 to 23.5 million in 2009, as Figure 1 shows. Many of the new fiber deployments will involve PONs.

Future wavelength PONs will be based on dense wavelength division multiplexing, a technology that puts data from different sources together on an optical fiber, with each signal carried on its own light wavelength. These PONs, which are still a few years off, would provide a separate wavelength of light for connections to and from each node.

Competition from present and future network-access technologies could pose the greatest challenge to PONs' long-term success, Shumate said. If PONs can't compete on price, potential users will choose cable, wireless, and other broadband technologies instead.

George Lawton is a freelance technology writer in Brisbane, California. Contact him at glawton@glawton.com.

Editor: Lee Garber, *Computer*, l.garber@computer.org