tellabs®

Get Ready for WDM-PON

Emerging standards could increase PON bandwidth and help expand fiber capabilities.

By Joan Engebretson

The more bandwidth consumers get, the more they seem to want. Just a few years after service providers began to deploy Passive Optical Networks (PON) based on Broadband and Ethernet (BPON and EPON) standards, some are already beginning to use higher bandwidth Gigabit PON (GPON) for new builds. And their migration plans don't stop there.

A hot topic today is which form the next generation of PON will take. Many vendors and service providers are gravitating toward an emerging PON architecture known as Wave Division Multiplexing PON (WDM-PON), which increases bandwidth by dividing a single fiber into multiple wavelengths, each capable of carrying the same bandwidth that previously required an entire fiber.

"Service providers are seeking more utility out of their deep-fiber access infrastructure," said Tim Doiron, director of broadband product marketing for Tellabs. "A multiple wavelength system provides that."

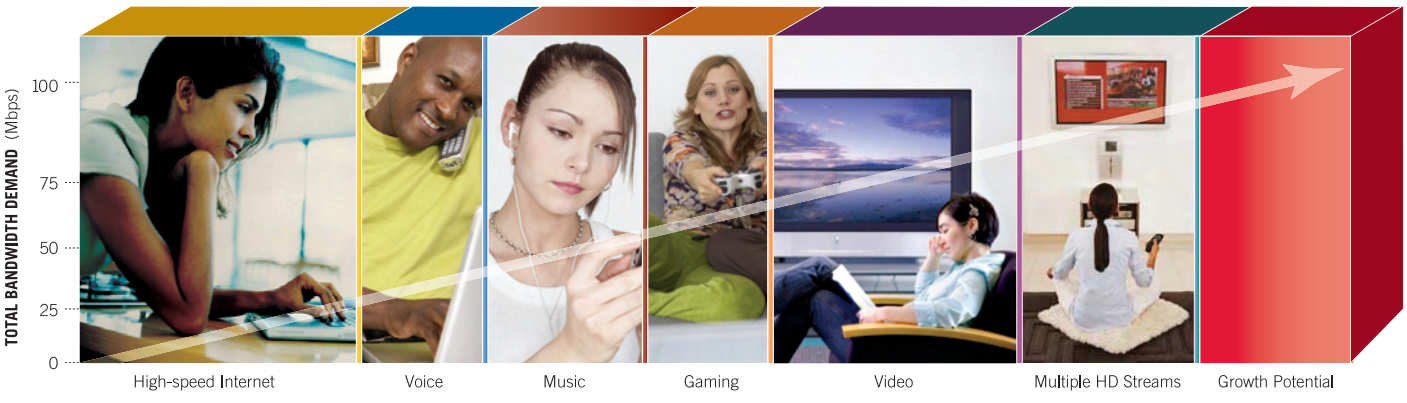
PON's Evolution

Today's PON systems based on BPON, EPON or GPON use two critical devices: an Optical Line Terminal (OLT), which is typically located in the Central Office (CO), and an Optical Network Terminal (ONT), which is located at the customer premises. A single fiber connects the OLT with a neighborhood node, where the signal is split into 32 fibers, each feeding an ONT.

GPON, the highest bandwidth PON system currently available, typically provides 2.5 Gbps downstream and 1.25 Gbps upstream. This bandwidth is shared by 32 users.

Although WDM-PON standards are still being developed, manufacturers and service providers anticipate that it will use the same physical architecture as today's PON systems, with an OLT feeding 32 ONTs. The difference is that each ONT will be fed by a separate wavelength, enabling each customer to get higher bandwidth. Some manufacturers, including Tellabs, already offer a form of wavelength PON for customers that use an extra downstream wavelength to

Bandwidth Drivers



support broadcast video services. WDM-PON expands on that idea by increasing the number of wavelengths in the fiber from the OLT to a neighborhood node.

One carrier, Korea Telecom, has already completed a limited deployment of a pre-standard WDM-PON system. Meanwhile, industry groups have begun work on WDM-PON standards. Standards bodies involved include the Full Service Access Network (FSAN), which drove the original BPON and GPON standards, and the Institute of Electrical and Electronics Engineers (IEEE), which developed the EPON standard.

Tellabs strategists involved with planning WDM-PON — including Doiron, Tellabs Fellow Rick Younce and Senior Engineering Manager Muneer Zuhdi — anticipate that WDM-PON standards initially will specify 100 Mbps per customer. Longer term, WDM-PON could support virtually unlimited bandwidth because it can carry virtually any data format, including Ethernet and Asynchronous Transfer Mode (ATM), all of which continue to evolve.

PON Technologies

	BPON	GPON	EPON
Standards	ITU-T G.983	ITU-T G.984	IEEE 802.3ah
Service Optimization	ATM	GEM	Ethernet
Bit Rates	Up to 622 Mbps	Rates specified are up to 2.5 Gbps. The most common rates deployed are 2.5 Gbps down/1.2 Gbps up.	Up to 1.2 Gbps symmetric
Split Ratio	1:32	1:32 Class B+ optics	1:16 Class PX20 optics
Wavelength Plan	1490 nm down, 1310 nm up, 1550 nm specified as enhancement band	1490 nm down, 1310 nm up, 1550 nm specified as enhancement band	1490 nm down, 1310 nm up, 1550 nm specified as enhancement band

Demand Drivers

How soon are customers likely to demand 100 Mbps connectivity? The answer depends partly on the arrival of emerging applications such as high-definition and three-dimensional video, which could consume even more bandwidth as services become increasingly personalized, providing a separate channel to each user in the home. Advanced gaming applications could also be a major driver.

"The gaming and television experiences will likely merge down the road," Doiron said. "You could be wearing a full-body suit to track your motions as you play advanced three-dimensional games with people around the world. Think of it as Nintendo® Wii on steroids."

Although such applications could take a few years to materialize, some service providers envision using WDM-PON sooner to support business customers or other heavy users of bandwidth. Zuhdi calls such consumers "power users." Because power users would represent only a portion of the customer base, they would likely be served via an overlay network.

That's just one reason why it's critical for WDM-PON to co-exist with other PON infrastructures, particularly GPON, which is being deployed at a faster rate than the other PON technologies. Co-existence with earlier-generation PON technologies will be a critical focus of emerging WDM-PON standards currently under debate by the FSAN and IEEE groups.

Each of the existing PON technologies uses upstream and downstream wavelengths at different nanometers, which could create incompatibilities unless the wavelength grid for WDM-PON is set up to avoid using those wavelengths. An additional level of complexity is introduced by PON systems that use an extra downstream wavelength for broadcast video. However, most service providers using those systems plan to eventually move away from the broadcast approach, presumably eliminating the need for that wavelength.

To address grid-related concerns, Zuhdi believes WDM-PON standards will likely include several different "flavors" based on different wavelength grids. Careful selection of the right WDM-PON wavelength grid would enable service providers to add WDM-PON to an existing PON by changing a line card module and doing a software upgrade at the OLT. With that approach, Doiron said, "A GPON ONT could be utilized and deployed side-by-side with a wavelength or WDM-PON ONT."

Although most service providers envision relatively small demand, if any, for WDM-PON in the near term, they are taking keen interest in its development because they want to ensure that future upgrades can be handled smoothly. "Whether they see an immediate need doesn't matter," Zuhdi said. "They want to make sure they know how the system will evolve so they can minimize or negate having to replace ONTs in the field. They want to make sure that what they're shipping in volume can support this evolution and their investment."

Reducing System Costs

The FSAN WDM-PON standard is expected to be finalized by 2010, Zuhdi said. In the meantime, the technology's developers also are also focusing on how to reduce WDM-PON costs, which currently exceed GPON costs by a substantial margin.

With that goal in mind, several universities — including Georgia Tech, the Polytechnic University of Catalunya in Spain, Stanford and the University of Michigan — are each researching a different aspect of WDM-PON technology. Tellabs is helping to fund the Catalunya and University of Michigan research projects, both of which are aimed at reducing the cost of the ONT, but from different vantage points.

"The research at Catalunya is more at the systems level," Younce said. "The University of Michigan work is more device-specific."

One way to reduce the cost of the ONT is to minimize the need for expensive lasers. University of Michigan researchers hope to do that through the use of a reflective device, which is the focus of their project. Catalunya researchers, meanwhile, aim to address the challenges involved with using reflective devices. "The challenge is

crosstalk resulting from fiber nonlinearities and reflections," Zuhdi said. "Researchers are investigating several methods to mitigate this problem."

On the ONT cost issue, Zuhdi explained: "Basically the cost of the ONT is a big contributor to the overall cost per customer. Therefore, we cannot afford to use expensive tunable lasers at each ONT. The two key technologies that have the potential to replace tunable lasers are injection-locked Fabry-Perot lasers and reflective semiconductor optical amplifiers." Zuhdi believes that a cost-effective solution at the ONT will drive the success of WDM-PON, with the choice of wavelength grid also playing a role.

As developers consider the ONT for WDM-PON, they are also rethinking some of the assumptions they made for earlier-generation systems. One is the decision to locate the ONT outdoors or in a customer's garage. "There is a lot of discussion about whether fiber to the office is the right model," Doiron said. "That approach would drive the development of a true indoor ONT that looks like a cable modem," Doiron said. "The question then is 'What does the fiber inside the house look like?' Potentially you could use relatively inexpensive plastic fiber. Our thinking is evolving as we plan."

Developers are also considering the possibility of using WDM-PON to extend the distance between a broadband customer and the CO, which is currently limited to 20 km with BPON, GPON and EPON.

WDM Comes to MSPPs

The idea of using Wavelength Division Multiplexing (WDM) to increase bandwidth is spreading beyond Passive Optical Networking (PON) to play a role in Multiservice Provisioning Platforms (MSPP). MSPPs enable both Time Division Multiplexing (TDM) and non-TDM traffic — such as Ethernet — to be carried over a Synchronous Optical Network (SONET) or Synchronous Digital Hierarchy (SDH) transport infrastructure. Like other parts of metro networks, there is a huge increase in bandwidth demand to support wireline and wireless carriers' video and high-speed data offerings. By dividing a fiber into multiple wavelengths, each capable of carrying the same bandwidth that previously required the entire fiber, WDM can provide an excellent means to increase the capacity of MSPPs. It's also particularly useful when carriers have little or no fiber to spare.

To accommodate this trend, Tellabs recently introduced a WDM-based version of the Tellabs® 6325 Edge Node. "The Tellabs® 6325 node is one of the most advanced Ethernet-over-SDH products you can get," said Frank Ebskamp, group product manager for Tellabs' transport division in Denmark. The Tellabs 6325 WDM node's advanced features include fully protected SDH switching, Plesiochronous Digital Hierarchy (PDH) transport, Ethernet switching and Multiprotocol Label Switching (MPLS), and support for a wide range of interfaces, including SDH, PDH, Ethernet, Gigabit Ethernet and Fiber Channel.

Another important feature of the Tellabs 6325 WDM node is its compact size. A compact form factor is critical to network operators because it lets them maximize the space available in their Central Offices (CO) as they increase bandwidth and the amount of equipment to support that bandwidth. "A compact size will be overridingly important as network operators add WDM capability to their MSPPs," Ebskamp said.

The Tellabs 6325 WDM node occupies 1RU rack space and accommodates eight Coarse WDM (CWDM) and eight Dense WDM (DWDM) channels. It also supports four-channel muxponder or transponder/repeater modules in addition to the existing PDH, SDH and Ethernet functions. The modules are about the size of a CD-ROM drive and can accept a range of pluggables, each operating at a different wavelength and measuring about half the size of a ballpoint pen.

The pluggable approach helps enable operators to tailor the system as needed to meet bandwidth demands and support interconnection with transport network devices, such as the Tellabs® 7100 Optical Transport System (OTS) and the more compact Tellabs® 7100 Nano Optical Transport System (OTS). "By using various pluggables, operators can configure the equipment with different wavelengths to work with a host of WDM-compatible products," Ebskamp said.

A variety of factors determine which node is the best fit. "In WDM transport networks, you would need the Tellabs® 7100 OTS and Tellabs® 7100 Nano OTS because you need the large capacity and flexibility that a Reconfigurable Optical Add/Drop Multiplexer (ROADM) can offer," Ebskamp said. "But in aggregation networks, you only need to bring streams of traffic onto the Tellabs 7100 OTS and Tellabs 7100 Nano OTS. The Tellabs 6325 node goes hand-in-hand with those products, just as SONET networks would have different levels of equipment tied together."

The Tellabs 6325 WDM node can be viewed as one element of a complete WDM platform. "WDM becomes not just a product, but a technology capability that is available in multiple products," Ebskamp said. And because the Tellabs 6325 WDM node can use both CWDM and DWDM, it can support as many as 15 wavelengths to offer significant expansion capability. "It's the best choice for scaling to larger bandwidth and longer distances," Ebskamp said.

A distance increase should be possible, Zuhdi said, because WDM-PON will likely use an Array Waveguide Grating (AWG) mechanism in place of the power splitter used at the neighborhood node with today's PON systems.

"The power splitter splits the signal between 32 users, and every time it is split, there is loss," Zuhdi said. "With an AWG, the loss that each wavelength experiences is less than with the power splitter. The loss will be around 5 dB, versus 18 dB with a power splitter. That could translate into 48 km or so of added distance. You could achieve longer reach or reach more users in the form of a hybrid TDM/WDM-PON."

More Flexibility, More APPS

The chief appeal of WDM-PON will be its flexibility, said Teresa Mastrangelo, principal analyst for broadbandtrends.com. "It allows for some customization of services to the end user and may allow service providers to better address the super-users without having to rework their entire network to support them," she said. WDM-PON could also lend itself more easily to a wholesale market approach than some other broadband technologies because the infrastructure owner could let other network operators offer their own services over individual wavelengths, Mastrangelo said.

The added level of security that WDM-PON provides could also be appealing for some applications. With traditional PON systems, traffic destined for each of the 32 users is sent to all 32 locations, and each user's network interface filters out the traffic that is not intended for that user. By comparison, WDM-PON dedicates a private path from each customer to the CO. "You would have a more secure infrastructure and could offer a much different type of commerce experience," Mastrangelo said. "It could be more transaction-oriented."

WDM-PON is not the only evolutionary path for WDM under consideration. Some companies are talking about increasing GPON's bandwidth to 10 Gbps. But WDM-PON's flexibility could help it win out over more traditional PON alternatives. "Network operators may skip 10-Gig PON and go straight to WDM-PON," Mastrangelo said.

By offering flexibility and potentially limitless bandwidth, WDM-PON appears destined — sooner or later — to play an important role in carrier networks.

North America

Tellabs
One Tellabs Center
1415 West Diehl Road
Naperville, IL 60563
U.S.A.
+1 630 798 8800
Fax: +1 630 798 2000

Asia Pacific

Tellabs
3 Anson Road
#14–01 Springleaf Tower
Singapore 079909
Republic of Singapore
+65 6215 6411
Fax: +65 6215 6422

Europe, Middle East & Africa

Tellabs
Abbey Place
24–28 Easton Street
High Wycombe, Bucks
HP11 1NT
United Kingdom
+44 870 238 4700
Fax: +44 870 238 4851

Latin America & Caribbean

Tellabs
1401 N.W. 136th Avenue
Suite 202
Sunrise, FL 33323
U.S.A.
+1 954 839 2800
Fax: +1 954 839 2828

74.1885E Rev. A 9/07