Battle of the PONs
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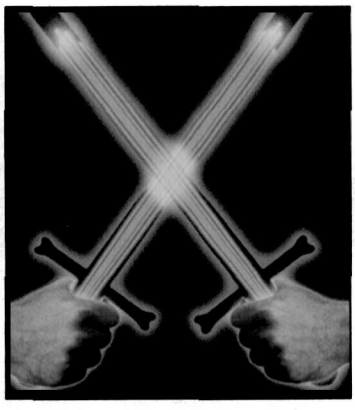

Battle of the PONs

Operators rolling out FTTH have to weigh up the pros and cons of numerous optical access architectures

written by
Ken Wieland

FTTH is one of the hottest topics in telecom. Rolling out fibre from the central office to the home or building allows operators to offer more bandwidth to more customers than is possible with DSL technology. In doing so, FTTH should open the door to new revenue, and could be a way to attract new customers and reduce churn.

For those operators convinced by FTTH, there are a bewildering number of optical access architectures to consider. Within the passive optical networks (PON) family, there is BPON, GPON, EPON (sometimes referred to as GePON) and EP2P (Ethernet Point-to-Point). And, for next-generation PONs, operators will need to keep an eye on 10G PON and WDM-PON developments.

Given the plethora of options available, will any single standard emerge victorious? Oren Marmur, CTO at FlexLight Networks, a US-based GPON vendor, doesn't think so. "There isn't going to be one universal standard," he says. "Operators will choose what fits them best, which will mean different PON solutions being adopted."

It will also mean an ongoing debate about which is best. Vendors, with different vested interests, will ensure that a PON battle of some sort takes place.

The passive view

A PON, by definition, has no active electronic components located at an 'intermediate' point between the central office and the customer. The architecture simply comprises an optical line terminal (OLT), based in the central office, and an optical networking terminal (ONT), based on the customer premise.

To connect the OLT and the ONT with data, a single strand of fibre carries a wavelength downstream. By using a passive splitter (which splits the light wave) the downstream data originating at the OLT can be distributed. A series of passive splitters may have to be located within the PON architecture to reach the required number of customers. This is a point-to-multipoint architecture.

The upstream data running from the ONT to OLT — which is delivered on a separate wavelength to avoid collisions with the downstream transmission — is aggregated by the same passive splitter unit, which also carries out the recombining function. This enables data to be collected by the OLT over the same single fibre that sends the traffic downstream.

The first of the major point-to-multipoint PON variants to arrive was ATM-based BPON (Broadband PON). Standardised by the ITU in 2001, one BPON allows 32 users to share up to 622Mbps on the downstream and up to 155Mbps on the upstream. Although adopted widely in North America, BPON lacks the bandwidth to carry video and TV services. If a BPON were fully loaded (32 users all requiring 'high-speed' connectivity), FlexLight calculates that each customer would get a maximum guarantee of around 13Mbps on the downstream and 3Mbps on the upstream (assuming a bandwidth efficiency of around 70 per cent). A pristine high-definition TV channel soaks up around 10-12Mbps, so BPONs don't give operators much room for manoeuvre.

The arrival of Gigabit PON (GPON), standardised by the ITU in February 2004, with 2.48Mbps on the downlink — and the ability to support up to 64 users — is a big improvement. GPON can also, through the use of GPON

Encapsulated Mode (GEM), support ethernet, TDM and ATM. Operators using the GPON can continue to offer 'legacy' services — such as TDM-based voice and leased lines — without having to change customers' premise equipment. Verizon in the US has said that it will go from BPON to GPON in 2007.

But while GPON is arguably seen as the 'natural' evolution of BPON, Ethernet PON (EPON) is also a major PON contender. Using ethernet interfaces, an EPON can deliver symmetrical speeds of 1.25Gbps to 32 users.

Table 1

Performance comparisons of BPON, GPON and EPON

	BPON	GPON	EPON
Standard	ITU (G.983)	ITU (G.984)	IEEE (802.3ah)
Data capacity	622Mbps/155Mbps	2.48Gbps/1.24Gbps	Symmetrical 1.25Gbps
Subscriber capacity	32 users	64 users	32 users
Dynamic bandwidth allocation (DBA)	Assuming a bandwidth efficiency of 70%, each customer would get a maximum of around 13Mbps on the downstream and 3Mbps on the upstream — 20% more with DBA	In a GPON supporting 32 users, Alcatel-Lucent asserts that users can have 'sustained rates' of 80Mbps	NTT, through DBA, is offering its customers between 30Mbps and 100Mbps

Source: The FTTx Mini-Guide

Japan: GPON not in the frame

For GPON supporters, the fact that the world's largest FTTH deployment is based on EPON is a bit of a nuisance. NTT, through its two subsidiaries — NTT West and NTT East — has over six million FTTH subscribers and is forecasting 30 million by the end of 2010.

To explain this awkward fact, one spokesperson for Alcatel-Lucent — a heavyweight vendor of GPON equipment — suggested at a recent conference organised by IDATE, a France-headquartered research and consultancy organisation, that NTT moved from BPON to EPON in 2004 simply because GPON wasn't available at the time.

This is not the view of NTT. "It was a simple and natural decision for us to select EPON," says Hiromichi Shinohara, vice president at NTT Access Network Service Systems Labs. "EPON gives us cost reductions."

That's because a large number of residential and business users in Japan have already moved from legacy leased-line services to ethernet leased-line services, explains Shinohara. Moreover, NTT has a full-IP backbone network in place; switches and routers in this network also use ethernet interfaces.

"Due to the prevalence of ethernet UNIs [user network interfaces] and ethernet NNIs [network-to-network interfaces], it's more efficient [for us] to transport data on an ethernet frame rather than converting from ethernet to a GEM frame," says Shinohara.

And, importantly for EPON supporters, NTT has proved that ethernet can be 'carrier class' in the access portion of the network. "The 802.3ah [EPON standard] specifies only the physical and MAC layer," says Shinohara, "but we have realised a carrier-grade EPON system by implementing authentication, encryption and DBA [dynamic bandwidth allocation] functions."

The EPON camp can also argue that it enjoys greater economies of scale than GPON — at least for the time being. After all, GPON is a relatively new standard and vendor interoperability is bound to be an issue over the next couple of years.

But GPON supporters are equally keen to point out its advantages. First of all, in terms of overall bandwidth efficiency, they claim to have the upper hand over EPON because GEM uses 8 bits and not 10 bits to encode the data stream. GPONs — they say — are 20 per cent more efficient then ethernet as a link layer protocol.

What's more, 32 GPON users can share 2.48Gbps on the downstream link, while the 32 EPON users have access to 'only' 1.25Gbps. Alcatel-Lucent even suggests that a GPON can provide 'sustained rates' of 80Mbps to individual customers.

GPON's bandwidth advantage over EPON is not something that NTT sees as significant. As with all PON architectures that require customers to share bandwidth, NTT's FTTH service is a best-effort one, but it can rely on the 'bursty' nature of the PON to increase throughput. This is where the bandwidth not being used by some users can be allocated to others who require it (and which helps explain Alcatel-Lucent's 80Mbps claim). It is this PON characteristic, according to Shinohara, that negates GPON's advantage. "We can offer customers between 30Mbps and 100Mbps," he says, "so I think that 1Gbps shared between 32 users is sufficient for the time being."

In fact, one of the main FTTH challenges that NTT faces is how to steer customers' operator selection criteria *away* from data speed and towards services, whilst meeting customers' demands for greater bandwidth when they actually need it.

While it is easy to be swayed by the arguments on either side, one indisputable advantage of GPON is that it is backwards compatible with BPON. This means that operators moving from BPON to GPON can use existing outside fibre plant. The major US operators, which use BPON architectures, insisted on backwards compatibility within the GPON specification.

By contrast, NTT — which widely rolled out BPON in 2002 — cannot run EPON and BPON over the same fibre. For its EPON rollout, it has to install a new outside fibre plant, which increases opex and capex.

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gate against spectral interference (FEXT crosstalk) in the copper plant.

Simply put, DSM can coordinate the DSL transmitters that share the same copper loop infrastructure, thus enhancing spectrum utilisation. Service providers can then perform preventative line maintenance by identifying troubled lines and automatically making necessary adjustments to improve line performance without the customer ever knowing there's a problem.

By mitigating against spectral interference, DSM promises to enhance the performance and management of the DSL service.

Leading the initial charge for DSM are vendors such as John Cioffi's ASSIA (Adaptive Spectrum and Signal Alignment Incorporated) and ECI Telecom.

ASSIA, along with AT&T (fomerly SBC) previously entered into a joint agreement to develop what was to be called a 'DSL optimiser' software tool that incorporates DSM to help AT&T monitor and automatically allocate spectrum to improve DSL performance.

Meanwhile, ECI Telecom has launched the DSM Consortium. Consisting of large telecom operators (Telefónica and Bezeq), vendors (Actelis) and major universities (Bar Ilan University and Tel Aviv University), the DSM Consortium aims to promote the ongoing development and implementation of DSM.

Ariel Shuper, director of product management for ECI Telecom, argues that DSM can help to future-proof the existing copper network.

"Telecom service providers say: 'I know how costly and complex it is deploy FTTH, and there's a chance that this new technology [DSM] will let me use the copper and secure my investment in my street cabinets. I want it to last a few more years,'" he explains. "DSM seems very promising, at least from the theoretical level. You can really enhance the reliability and therefore enhance the bandwidth, which is achievable if you go for the highest level of DSM."

So, while the drive to get fibre to every customer will continue to be the dream, the reality is that there's still plenty of life in that copper line. ◂

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FTTx

What is the point-to-point?

The point-to-multipoint architectures of BPON, GPON and EPON, however, are not the only PON game in town. In an Ethernet P2P architecture (EP2P), a dedicated fibre runs between the ethernet switch (located at the central office) and the end user. The Iliad Group in France is using EP2P for its plan to pass ten million customers with fibre by 2012.

Predictably, the GPON camp is quick to pounce on what it sees as EP2P deficiencies. They argue that a point-to-point system requires more opex and capex than a GPON because of the need for dedicated optical ports in the central office and more outside plant. For one central office to service 16,000 customers, Alcatel-Lucent asserts that GPONs require 80 per cent less power at the central office than an EP2P architecture and use 92 per cent less floor space. EP2P opex, according to Alcatel-Lucent, works out at €35 more per year per subscriber compared to a GPON on a like-for-like basis.

On the flip side, EP2P supporters say they can offer higher bandwidth than point-to-multipoint architectures. Although a GPON — through statistical multiplexing and the dynamic bandwidth allocation — can offer downstream speeds of up to 100Mbps, EP2P would be able to *guarantee* that performance (both upstream and downstream) regardless of the bandwidth usage patterns of other customers on the same PON.

And for operators expecting customers' bandwidth requirements to eventually exceed 100Mbps, EP2P has the attraction of apparent greater flexibility to evolve. Through using established ethernet standards, it can increase bandwidth performance by swapping line cards at the central office to support 1Gbps or 10Gbps per port. The evolution of GPON to 10G PON or WDM-PON has still to go through the standardisation process.

However, point-to-point architectures are probably not for operators that doubt the maturity of IPTV technology and want to offer TV and video services of their own. They cannot support radio frequency (RF) overlay.

RF overlay is an extra wavelength on the point-to-multipoint PON dedicated to broadcast TV services; it is supported by the BPON, GPON and EPON standards. As a mature technology, it has a proven track record of delivering TV services on a mass-market scale. Verizon, notably, is using a hybrid RF overlay and IPTV approach for its FiOS TV service: RF overlay for broadcast TV and IPTV for video-on-demand. The operator has said openly that it doesn't believe IPTV is yet ready to deliver a mass-market video service.

The battle of the PONs, clearly, is not about to end anytime soon. ◂

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Some of the content of this article is taken from The FTTx Mini-Guide, which includes a detailed overview of the pros and cons of PON and AON FTTH architectures. A collaboration between Nexans and Telecommunications®, The FTTx Mini-Guide will be available for download from the first week of February at www.telecommagazine.com