

The FTTx Mini-Guide

Table of Contents

Introduction	5
1 FTTx definitions.....	6
1.1 Overview	6
1.2 FTTH.....	6
1.3 FTTB	6
1.4 FTTN.....	7
2 FTTH/FTTB architectures and performance.....	7
2.1 Overview	7
2.2 Passive optical networks.....	8
2.2.1 Overview	8
2.2.2 TV and video services.....	9
2.3 Outside plant construction	11
2.3.1 Overview	11
2.3.2 Components.....	11
2.3.3 Fibre-optic cable performance	12
2.4 PON variants	12
2.4.1 BPON	12
2.4.2 GPON.....	13
2.4.3 EPON.....	14
2.4.4 GPON versus EPON	15
2.4.5 EP2P (Ethernet Point-to-Point)	16
2.5 Next-generation PONs	17
2.6 Active optical networks	18
2.6.1 Overview	18
2.6.2 AON versus PON	18
3 FTTN architectures and performance	19
3.1 Overview	19
3.2 FTTN+VDSL.....	20
3.3 FTTN+VDSL2.....	20
3.4 FTTN+VDSL/VDSL2 versus FTTH/FTTB	22
3.5 Enhanced xDSL cables	22

4	Factors affecting FTTx deployment	23
4.1	Overview	23
4.2	Bandwidth requirements	23
4.2.1	Overview	23
4.2.2	The 'bandwidth-hungry' contenders	24
4.3	Cost per FTTx subscriber	26
4.3.1	Overview	26
4.3.2	Cost-reduction methods	26
4.4	The regulatory environment	27
4.4.1	Overview	27
4.4.2	EU Regulatory Framework	28
4.4.3	The 'horizontally-integrated' business model	29
5	FTTx deployment status	29
5.1	Europe	29
5.2	North America	30
5.3	Asia	30

Tables

Table 2.1:	Key performance characteristics and features of BPON	13
Table 2.2:	Key performance characteristics and features of GPON	14
Table 2.3:	Key performance characteristics and features of EPON	15

Figures

Figure 2.1:	A point-to-multipoint PON architecture	9
Figure 3.1:	Performance characteristics of ADSL2+, VDSL and VDSL2	21
Figure 4.1:	Different TV and HSI service scenarios using 20Mbps	24
Figure 4.2:	Capex comparison for different FTTx architectures	27

Introduction

In recognition of the growing importance of optical fibre in the access network, Nexans – a global expert in cables and cabling systems – and *Telecommunications*® have collaborated to produce The FTTx Mini-Guide. Our intention is to provide a clear and objective overview of the various FTTx architectures that are available, as well as highlighting the key drivers for investment.

The need for objective and accessible information on this potentially complex subject has never been greater. As operators start to offer more bandwidth-hungry services, such as triple play and IPTV, important questions now need to be asked about *how* these will be delivered to the customer over the ‘last mile’.

For over a hundred years, copper connections between the central office and the customer have been sufficient. The evolution of DSL technology – which boosts the data performance of the copper-based last mile – has also allowed operators to use their legacy networks to offer ‘high-speed’ Internet access of between 8Mbps and 16Mbps¹.

But is that enough? The general industry consensus is that it won’t be, particularly in markets where demand for high-definition TV (HDTV) and interactive applications takes off. And if customers want more bandwidth than what an all-copper last mile can deliver, other network architectures need to be considered.

The main candidate to replace copper in the last mile is optical fibre, which, in certain network configurations, can deliver downstream and upstream speeds of more than 100Mbps to the customer. But even if operators do decide that fibre is the best way forward, they still need to address a number of key questions about how to maximise their return on investment. Do they roll out fibre to the node or all the way to the home/building? Do they deploy a passive or active optical network? And if they do deploy a passive optical network (PON), which variant should they opt for? And, perhaps most crucially of all, *when* do operators need to roll out their chosen fibre access architecture?

There is also a wider, political context for FTTx. Governments recognise that higher-speed access networks and IT have the potential to make national and regional economies stronger. Given the prominent position that FTTx now occupies on the agendas of operators, regulators and policy-makers, Nexans and *Telecommunications*® intend this booklet to be a handy and indispensable information resource on the key issues that surround optical fibre in the last mile.

1 ADSL2+ is theoretically capable of delivering 24Mbps but only to customers who are located less than 300 metres from the central office or remote DSLAM

1 FTTx definitions

1.1 Overview

The FTTx acronym is widely understood as Fibre-to-the-X, where X can denote a number of destinations. These include Home (FTTH), Premise (FTTP), Curb (FTTC), Building (FTTB), Home (FTTH), User (FTTU) and Node (FTTN). Clearly, however, there are overlaps in meaning. FTTP is similar to FTTB, and FTTC resembles FTTN.

There is also scope for confusion. While the US tends to use FTTP it could have the connotation of FTTH in Europe, yet the two terms do not necessarily mean the same. The former could include instances when the fibre-optic link does not fully extend to the home environment, whereas FTTH usually assumes it will. And the use of different terms, as the FTTH Council² points out, can make it impossible to usefully compare FTTx studies from different research firms.

To avoid an unnecessary proliferation of acronyms – and to reduce the potential for misunderstanding – the FTTH Councils for North America, Europe and the Asia-Pacific region published an agreed definition of terms in September 2006. As the focus of the FTTH Council is on promoting fibre-optic architectures that run as deep as possible into the network – that is, nearest to the subscriber – it narrows down its focus to two FTTx variants: Fibre-to-the-Home (FTTH) and Fibre-to-the-Building (FTTB).

A summary of the two definitions is as follows:

1.2 Fibre-to-the-Home (FTTH)

A fibre-optic communications path that extends from the operator's switching equipment to at least the boundary of the home living space or business office space. The definition excludes those architectures where the optical fibre terminates before reaching either the home living space or business office space and where the access path continues over a physical medium other than optical fibre.

1.3 Fibre-to-the-Building (FTTB)

A fibre-optic communications path that extends from the operator's switching equipment to at least the boundary of the private property enclosing the home(s) or business(es). In this architecture, the optical fibre will terminate before reaching the home living space or business office space. The access path will then continue over another access medium – such as copper or wireless – to the subscriber.

² The FTTH Council comprises three regional branches: North America, Europe and Asia. Each branch is a non-profit organisation seeking to accelerate the adoption of FTTH/FTTB in its respective region

However, these two definitions don't cover those cases where the fibre-optic communications path terminates at a so-called 'intermediate' distribution point in the local access network to serve a set of homes and/or buildings. This is generally referred to as Fibre-to-the-Node (FTTN), which we will define as follows:

1.4 Fibre-to-the-Node (FTTN)

A fibre-optic communications path that extends from the operator's switching equipment to a point further away from the subscriber than that defined in FTTH or FTTB. This can include the Curb or Cabinet (FTTC) or some other 'intermediate' point between the central office and the subscriber. The access path between the intermediate point and the subscriber is not optical fibre but another transmission medium, such as copper or wireless. For the purposes of The FTTx Mini-Guide we will restrict the scope of FTTx to FTTH, FTTB and FTTN. Only when operators or vendors make specific references to other 'X' variants will we refer to them.

2 FTTH/FTTB architectures and performance

2.1 Overview

For operators rolling out FTTH and FTTB, they have a number of network architecture options to consider. These options can be divided into two broad categories:

- **PONs** (passive optical networks), which require no active electrical components between the end-user and the central office; and
- **AONs** (active optical networks), where active electrical components are installed between the end-user and the central office.

Under the PON umbrella, three major point-to-multipoint variants have emerged: BPON (Broadband PON), GPON (Gigabit PON) and EPON (Ethernet EPON). While BPON, based on expensive ATM (asynchronous transfer mode) interfaces and comparatively low throughput speeds, is now arguably the least attractive of the three main PON options, there is as yet no single PON winner to emerge from a global perspective.

In the US, Verizon has decided to move from BPON to GPON during 2007, while NTT in Japan – the world's largest FTTH operator through its two subsidiaries, NTT West and NTT East – opted in 2004 to go from BPON to EPON. Many incumbent operators in Europe are still weighing up their FTTH/FTTB strategies and have yet to make a firm commitment on their preferred network architecture.

By contrast, a number of alternative operators and municipalities have shown a leaning towards AONs. Fastweb (Italy) and B2 (Sweden), both alternative operators, are responsible for two of the largest AON rollouts in Europe.

Some large FTTH city projects in Europe, instigated by local government, have also adopted AON architectures. Amsterdam and Vienna are two notable examples. By contrast, the local government of Asturias – a principality in northern Spain – has opted for a PON architecture.

2.2 Passive optical networks

2.2.1 Overview

The PON architecture comprises an optical line terminal (OLT), based in the central office, and the optical networking terminal (ONT) – sometimes referred to as an optical network unit (ONU) – based on the customer premise.

To connect the OLT and the ONT with data, a fibre-optic cable is used to carry a wavelength downstream. By using a passive splitter (which splits the light wave) the downstream data originating from 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, sometimes described as a tree.

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.

One of the key characteristics of the point-to-multipoint PON is 'bursty capacity'. This allows operators to allocate extra shares of the downstream bandwidth to users when they need it (on the assumption that not all other customers on the same PON are using their guaranteed bandwidth allocation at that moment in time). The dynamic bandwidth allocation (DBA) capability of the point-to-multipoint PON, say its protagonists, sets it apart from point-to-point PON and AON architectures.

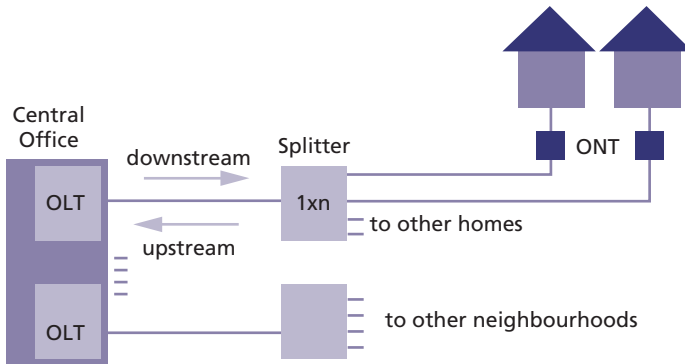


Figure 2.1: A point-to-multipoint PON architecture

Source: Conniq and Telecommunications®

2.2.2 TV and video services

As telcos turn to triple-play services (video, voice and high-speed internet access) to reduce churn and increase revenue, they need to find a way of delivering TV and video to the end-user as cost-effectively as possible. Each of the major point-to-multipoint PON variants – BPON, GPON and EPON – offers two different methods of offering TV/video service: RF (radio frequency) overlay and IPTV. However, point-to-multipoint PON operators could use both methods simultaneously for TV and video service delivery if they were seeking, say, a gradual migration to IPTV.

RF overlay

In a point-to-multipoint PON architecture, one wavelength frequency is assigned for downstream data and telephony (1490 nm) and another is assigned for upstream data (1310 nm). With the RF overlay approach, through the use of wave-division multiplexing (WDM), a third downstream frequency is assigned – 1550 nm – which is dedicated to video broadcast. RF overlay is capable of delivering all types of video service: analogue broadcast; digital broadcast and HDTV; and video-on-demand.

Advantages

- As TV broadcasting is assigned to a dedicated frequency it will not eat into the data throughput of the PON.
- It offers a comparatively short entry-to-market time to deliver TV services (no set-top boxes are needed for the delivery of analogue broadcast over coaxial cable in the home).

- Through the use of RF overlay, operators can gradually migrate to IPTV (by using both delivery systems simultaneously) without the need for external set-top conversion apparatus (assuming they have shipped hybrid IPTV/RF set-top boxes to their customers). This could be an important consideration for operators since IPTV, unlike RF overlay, is not yet a proven technology for delivering video services on a large scale³.

Disadvantages

- RF overlay can only create a 'me too' service. The only things to differentiate the telco's TV offering from that of the cable operator would be price and content.
- It becomes complex to offer VoD services without hybrid IPTV/RF set-top boxes. As the RF signal is one way, an RF adaptor must be installed at the customer premise to send 'requests' to the central office via the 1310 nm upstream frequency.

IPTV

In the IPTV environment, the video signal (collected at the IP headend and converted into IP data streams) is transmitted over the same IP link as data for high-speed internet access. The IP set-top box converts the IP data stream back into a video signal.

Advantages

- The telco can differentiate itself with high-quality video and sound, as well as provide a wide range of interactive and personalised services via IPTV unicasting (where a dedicated channel is delivered to the customer). This is not possible with RF overlay broadcasting. Unicasting provides an unlimited number of channels; the broadcast capacity of RF overlay is restricted by a finite amount of spectrum.
- For telcos serving both copper-based and fibre-based customers, IPTV removes the need for two management systems (RF overlay is not suitable for xDSL customers but IPTV is).

Disadvantages

- There is a risk that video will absorb too much of the operator's data capacity on the PON, which limits its ability to offer other services. (The video and data services share the same downstream frequency in an IPTV environment.) Through channel replication, however, it is possible to reduce the impact on video data consumption when ONTs attached to the PON

³ Verizon has opted to use a hybrid IPTV/RF overlay solution for its FiOS TV service. IPTV delivers the video-on-demand and RF overlay delivers broadcast digital video. It elected this approach on the grounds that IPTV has not yet proven its reliability to deliver a mass-scale video offering

want to receive the same broadcast information. In this instance, each ONT would receive the same signal managed by the OLT. Channel replication would not, of course, be an option with video-on-demand.

- IPTV set-top boxes are more expensive than standard digital set-top boxes, although increased volumes should narrow the cost gap.

2.3 Outside plant construction

2.3.1 Overview

The deployment of a PON architecture requires a number of outside plant components, including the optical distribution frame, splitters, splicing closures, and wall-mounted boxes on the home or the building. It also requires fibre-optic cables with specific performance characteristics, both in the indoor and outdoor environment.

The selection of cables and associated components, as well as how they are implemented in the network – including the splitting ratio – are key to optimising capex and to reducing opex. The network owner will require comprehensive expertise in these areas if PON investment is to be maximised.

2.3.2 Components

A key component of the PON architecture is the optical distribution frame (ODF), which houses the OLTs and is located in the central office. It has to be capable of a number of functions, including the connection to ports in different sections of the central office. Patching port connections enables operators to use their existing billing and management systems for PON customers, and requires fibre splicing and fibre coiling.

The placing of 1xn splitter – where '1' represents one incoming strand of fibre and 'n' the number of splits (in PON configurations, 'n' can represent 2, 4, 8, 16, 32 and 64) – is not normally located in the central office as this can increase capex on outside fibre plant. However, the operator may consider installing a 2xn splitter at the central office (where two incoming fibres are accommodated). The 2xn splitter can be used as a means by which operators can introduce a test function on the PON, which can be managed from the central office.

Accessible splicing closures, with a mechanical sealing system, is another key part of a flexible and scaleable PON architecture. The primary function of a splicing closure is to interconnect transport cables onto multiple distribution cables and, in turn, to enable multiple drop cables from the distribution cables themselves. To guarantee these functions while minimising capex, the closure has to be re-accessible and re-sealable for progressive PON deployment. Part of this flexibility requires the splicing closure to have a scalable splicing tray capability. This, in turn, provides scalability on the splitter ratio.

2.3.3 Fibre-optic cable performance

To maximise the component functions as outlined in 2.3.2, the selected cables need to have complementary features, such as small diameters and mid-span access capability. Mid-span access is where the cable can be stripped in the middle of a length in order to get access only to the selected fibres for splicing.

For multi-dwelling units where there is high subscriber density, operators have two choices of fibre-optic cable to go through the vertical riser: Low Smoke Zero Halogen (LSZH) cables with 'standard pull installation' or micro-blown cable with an associated Halogen Free Flame Retardant micro duct (see section 4.3.1 on 'blowing' fibre through micro ducts).

For low-density buildings, a drop cable for a single user can be installed directly from the basement. But in both cases (high-density and low-density subscriber buildings) the drop cables from the basement (or from the floor) to the subscriber flat – as well as the indoor fibre-optic cables that connect onto the ONT – bend-insensitive fibre has to be used. According to Nexans, the use of bend-insensitive fibre introduces an extra initial cost of 'a few percent' but reduces opex.

For the drop cable connection, an external transition box can be located against the wall of the subscriber. If no external transition box is used, the design of the drop cable must include double sheath to operate the transition between external environment conditions to internal LSZH requirements.

Once the fibre-optic drop cable penetrates the home, it is connected onto a wall-outlet box fitted with a connector adapter to connect the patch cord onto the ONT. All the cables, at this level of the network, have to include bend-insensitive fibre to maximise opex savings.

2.4 PON variants

2.4.1 BPON (Broadband PON)

The BPON standard (G.983) was adopted by the ITU in February 2001 and is an evolution of the APON (ATM PON) standard. Although it still uses the ATM transmission protocol, the BPON has a key feature that APON does not – the additional wavelength to support video services.

Much of the work to specify the BPON standard was done by the Full Service Access Network (FSAN) consortium, whose membership comprises a collection of Tier One fixed-line incumbents. Formed in 1995, the FSAN consortium's remit is to 'enable the large-scale introduction of broadband access networks through the definition of a basic set of requirements'.

Table 2.1: Key performance characteristics and features of BPON

Data capacity	In a typical BPON, customers share downstream speeds of up to 622Mbps; the shared upstream speed is up to 155Mbps
Subscriber capacity	Supports up to 32 users per tree with a recommended maximum distance between the OLT and ONT of 20km
Dynamic bandwidth allocation (DBA)	If a BPON were fully loaded (32 users all requiring 'high-speed' connectivity) each customer would get a theoretical maximum of around 13Mbps on the downstream and 3Mbps on the upstream (assuming a bandwidth efficiency of around 70%). Through statistical multiplexing, which assumes that not all customers will want high-speed connectivity at the same time, a BPON operator can usually offer its customers 20% more bandwidth ⁴
Protocol supported	ATM
Summary	While BPON accounts for the majority of early PON rollouts in the US and parts of Asia, it looks set to be superseded by other PON variants with better performance characteristics

2.4.2 GPON (Gigabit PON)

The GPON standard (G.984), adopted by the ITU in February 2004, is the most recent PON variant to emerge. It is the result of an FSAN consortium initiative back in 2001 to standardise a PON capable of delivering over 1Gbps.

The standardisation work exceeded initial expectations, however, as a GPON can deliver downstream speeds of up to 2.48Mbps. This can be shared by up to 64 customers. The higher subscriber capacity makes GPON much easier to scale than BPON.

Apart from its faster speeds and greater subscriber capacity, the most significant extra functionality that GPON offers over BPON is its ability to support multi-protocols in their native format. Using the GPON Encapsulated Mode (GEM), the GPON standard can support Ethernet, TDM and ATM. Operators using the GPON can therefore continue to offer 'legacy' services – such as TDM-based voice and leased lines – without having to change customers' premise equipment.

⁴ Source: FlexLight Networks

The FTTx Mini-Guide

Table 2.2: Key performance characteristics and features of GPON

Data throughput capacity	GPON customers share downstream speeds of up to 1.24Mbps or 2.48Mbps; the shared upstream speed is up to 622Mbps or 1.24Gbps ⁵
Subscriber capacity	Supports 32 users per tree at a recommended maximum distance between the OLT and ONT of 20km. If serving 64 users (the maximum GPON subscriber capacity) the distance between the OLT and ONT is reduced to 12-15km if maximum throughput is to be maintained. If the number of users drops to 16, the distance between the OLT and the ONT can extend to 30km ⁶
Dynamic bandwidth allocation (DBA)	The typical GPON benchmark is 2.5Gbps shared among 32 users. This can yield a 'sustained rate' of 80Mbps per subscriber ⁷
Protocol supported	ATM, Ethernet, TDM
Summary	Gaining momentum in North America and parts of Asia. As a relatively new standard, GPON interoperability between different vendors' equipment will be an issue in the short- to mid-term

2.4.3 EPON (Ethernet PON)

The EPON standard (IEEE 802.3ah), adopted by the IEEE in mid-2004, is an extension to the work done by the Ethernet in the First Mile (EFM) committee, which comprises vendors of Ethernet equipment. Using a point-to-multipoint architecture in the same way as BPON and GPON, EPON operators can take advantage of the maturity and prevalence of the Ethernet standard (particularly within the enterprise) and its associated economies of scale.

How far these economies of scale actually extend is a matter of some dispute. According to IDATE, a research and consulting firm, EPON-based ONTs are one to two times less expensive than their GPON and BPON counterparts. But this assertion is challenged by Alcatel-Lucent. The GPON vendor argues that the typical low price of an EPON ONT can be attributed to a comparatively short reach of 10km and a requirement for data only. By contrast, the GPON ONT is specified at 20km and often includes voice and support for RF video. If an EPON ONT and a GPON ONT were configured identically, says Alcatel-Lucent, there would be little difference in cost to produce either unit.

⁵ It is unlikely that operators will use this granularity feature as the cost of offering the highest GPON speed is not significantly greater than provisioning the lower speeds

⁶ Source: FlexLight Networks

⁷ Source: Alcatel-Lucent

Table 2.3: Key performance characteristics and features of EPON

Data throughput capacity	1.25Gbps on the downstream, 1.25Gbps on the upstream
Subscriber capacity	Supports up to 32 users per tree with a recommended maximum distance between the OLT and ONT of 20km
Dynamic bandwidth allocation (DBA)	NTT, the largest EPON operator in the world, provides its customers with downstream and upstream speeds of between 30Mbps and 100Mbps. The speed varies depending on how many customers are accessing the same PON simultaneously
Protocol supported	Ethernet only
Summary	Championed primarily by NTT, EPON currently enjoys higher volumes and economies of scale than other PON variants. This advantage should diminish as GPON rollouts ramp up in 2007 and beyond

2.4.4 GPON versus EPON

Supporters of GPON, inevitably, claim to have a superior standard compared to EPON. One senior executive of a major GPON vendor goes as far as to suggest that NTT chose to go for EPON in 2004 simply because GPON wasn't available at that time.

It's a claim flatly denied by NTT. According to a senior spokesperson for Japan's major fixed-line operator, NTT sees EPON as 'better suited' to the Japanese market than GPON and allows the Japanese operator to meet the bandwidth and quality of service requirements of its customers.

Due to the prevalence of Ethernet UNIs (user network interfaces) and Ethernet NNIs (network-to-network interfaces) in Japan, NTT asserts that EPON is much more cost-efficient and manageable than GPON as it is cheaper and simpler to transport data on an Ethernet frame than a GEM frame. It has no intention of deploying GPON in the future. "Opting for EPON was a simple and natural decision," says the NTT spokesperson.

In terms of overall bandwidth efficiency, GPON vendors claim the upper hand over EPON. Because GEM uses 8 bits and not 10 bits to encode the data stream, GPONs – they say – are 20% more efficient than Ethernet as a link layer protocol.

And in a white paper entitled *Comparing Gigabit PON Technologies: ITU-T G.984 GPON versus IEEE 802.3ah EPON*, FlexLight Networks – a vendor of GPON equipment – claims that GPONs have an overall bandwidth efficiency of 93% when supporting 'legacy services compared with a 49% bandwidth efficiency rating for EPONs. Historically, the GPON camp has also argued that Ethernet is not 'carrier class' but recent technological developments make this argument less convincing. Many

incumbent operators are now migrating their ATM platforms onto Ethernet switches and IP routers in both the backbone and metro area network. And in the access portion of the network, NTT says it has been able to modify the 802.3ah standard to implement all the functions required of a carrier network (authentication, encryption and dynamic bandwidth allocation).

One clear advantage that GPON does have over EPON is backwards compatibility with BPON. This means that operators moving from BPON to GPON can use existing outside fibre plant. By contrast, NTT – which widely rolled out BPON in 2002 – cannot run EPON and BPON over the same fibre. For its EPON rollout, NTT has to install a new outside fibre plant.

2.4.5 EP2P (Ethernet point-to-point)

In an Ethernet P2P architecture, a dedicated fibre runs between the Ethernet switch (located at the central office) and the end-user. As there is no active equipment located at an intermediate point, an EP2P architecture belongs to the PON family.

Advantages

A key advantage of EP2P compared to PON is higher bandwidth; it is capable of supporting symmetrical speeds of 100Mbps. Although a GPON – through statistical multiplexing and the dynamic bandwidth allocation – can offer downstream speeds of up to 100Mbps, an EP2P would be able to *guarantee* that performance regardless of the bandwidth usage patterns of other customers linked to the same central office.

And for operators that anticipate customers' bandwidth requirements to eventually exceed 100Mbps, the EP2P has the attraction of greater flexibility to evolve. Through using established Ethernet standards, it can increase bandwidth performance by simply swapping line cards at the central office to support 1Gbps or 10Gbps per port.

This advantage would only be real, however, if the cost per Gigabit Ethernet switch port were low enough on which to build a business case to deliver higher-speed services.

Disadvantages

Ethernet P2P detractors argue that a point-to-point system has far higher opex and capex requirements than a GPON due to EP2P's need for dedicated optical ports in the central office and more outside plant.

For one central office to service 16,000 customers, Alcatel-Lucent says that only one fibre rack would be required in a GPON environment. For an EP2P system serving the same number of subscribers, 24 fibre racks would be required. The result, says Alcatel-Lucent, is that GPONs require 80% less power at the central office than an

EP2P architecture and use 92% less floor space. P2P opex, according to Alcatel-Lucent, works out at €35 more per year per subscriber compared to a GPON.

Alcatel-Lucent further asserts that as an EP2P architecture requires more outside plant and central office equipment than a GPON, which results in higher capex requirements to the tune of 30%.

These claims are refuted by the Iliad Group, which is rolling out an EP2P network in France. While accepting that Ethernet P2P requires higher capex than a GPON, Iliad's CEO describes the comparative extra cost as 'marginal'⁹.

But for operators who have doubts about the maturity of IPTV technology and are looking to offer TV and video services, a point-to-point architecture would not be suitable as it cannot support RF overlay (see 2.2.2).

2.5 Next-generation PONs

The FSAN consortium, through its Next Generation Access (NGA) task group, is exploring different technologies to evolve optical access systems beyond GPON. The two main candidates are 10G PONs and WDM-PONs. 10G PONs enable one wavelength to carry 10Gbps capacity, which is shared in the same way as existing point-to-multipoint PON architectures. WDM-PONs allow multiple wavelengths to be carried over a single strand of fibre through the use of different frequencies.

One scenario of a WDM-PON is that a customer could receive a dedicated wavelength. How much data capacity each wavelength could optimally carry in relation to cost, as well as the practical number of wavelengths that a WDM-PON could support, are some of the key issues that the FSAN is exploring.

NTT views WDM-PON as the most-promising next-generation FTTH system, not least because of its potential to allow BPON and EPON to share the same fibre. Korea Telecom has already started trials of WDM-PON.

According to vendors, standardisation work on 10G PON could be completed by 2009 with commercial products available by 2011. A similar timetable is envisaged for WDM-PONs.

It is unlikely that the emergence of 10G PON or WDM-PON will signal the end of the GPON versus EPON debate. In March 2006, a 10G EPON study group was formed within the IEEE 802.3 working group to explore the possibility of a 10Gbps wavelength over an EPON architecture.

⁹ Michaël Boukobza, CEO, Iliad, speaking to Telecommunications® in December 2006

2.6 Active optical networks

2.6.1 Overview

An active optical network (AON) comprises an active Ethernet switch that acts as the intermediate point between the central office and the end-user. Theoretically, this switch is capable of delivering symmetrical speeds of 100Mbps to 32 users simultaneously.

This level of throughput could only be achieved, however, if the link between the remote Ethernet switch and the central office supported 3.2Gbps (32 x 100Mbps). As this is expensive, AON detractors say it is more likely that the AON operator will use similar assumptions about bandwidth usage patterns as PON operators and over-subscribe the AON on similar lines. This would negate the AON bandwidth advantage.

By contrast, AON supporters say that one of the key advantages they have over a PON architecture is that it is much easier to remotely manage the network to guarantee bandwidth throughput to individual customers. That's because an AON is 'intelligent' and the PON is 'dumb'.

The issue about bandwidth capability is part of the ongoing AON versus PON debate. The main arguments for and against AONs – in comparison with PONs – are outlined below.

2.6.2 AON versus PON

AON advantages

- Higher symmetrical bandwidth capability, which could become an even more significant advantage if demand for P2P and Web 2.0 applications increases rapidly (see 4.2.3).
- Greater bandwidth scalability. The ability to swap Ethernet line cards in the central office to increase bandwidth capability makes AONs far more flexible than PONs. By virtue of an active Ethernet switch, AONs have more sophisticated remote management tools than PONs to deliver pre-agreed bandwidth rates to specific customers as and when they are required¹⁰.
- To run and manage a PON, more expensive IP Layer 3 CPEs are required for the customer to access the services he or she has subscribed to; these CPEs also need to have Layer 3 security functionality. By contrast, an AON operator can move Layer 3 management into the distribution layer (Layer 2) and take advantage of cheaper Layer 2 CPEs. This also makes network management easier as the AON operator doesn't have to monitor every CPE.

- Easier to isolate faults remotely, which reduces the number of expensive truck rollouts.
- The way MDUs (multi-dwelling units) are clustered in a city might make it easier to build ring-designs – where the buildings are daisy-chained (which is possible with an AON) – than rolling out a PON-based tree architecture.

AON disadvantages

- Higher opex costs to maintain a multitude of remote active Ethernet switches.
- Potential difficulty of finding suitable locations for the Ethernet switches (which need to be fed with power). This is particularly true for alternative operators with no existing active elements in their access network.
- Higher capex costs associated with point-to-point architectures (see 2.3.5).
- Cannot support RF overlay.

3 FTTN architectures and performance

3.1 Overview

A fibre-to-the-node (FTTN) architecture comprises a fibre-optic link between the central office and an intermediate distribution point. From this distribution point, the home and/or building is served with voice and data through either a wireline or wireless connection.

If the existing copper plant is used for the ‘final drop’, which is usually the case with a FTTN architecture, then a remote DSLAM (Digital Subscriber Line Access Multiplexer) forms the distribution point. It cross-connects to the street cabinet, which already serves a set of local homes and/or buildings with copper connections.

In a hybrid fibre/copper FTTN architecture, the twisted copper pair connection between the end-user and the remote DSLAM uses VDSL (Very high bit-rate Digital Subscriber Line) technology. The ONU, co-located with the DSLAM, feeds the signals back to the central office via the fibre-optic link. It is possible to use BPON+VDSL in a FTTN architecture; Verizon says it is working on how to implement GPON+VDSL2.

10 A spokesperson for the City of Vienna FTTH project says that one of the major criteria for its selection of an AON over a PON was its open and flexible auto-provisioning system. There was, she says, no PON solution on the market with equivalent functionality

If a wireless connection is used for the final drop, an antenna forms the distribution point. WiMax (Worldwide Interoperability for Microwave Access) is the most promising candidate for FTTN in a hybrid fibre/wireless architecture.

The 802.16d WiMax standard, designed for fixed access, provides theoretical maximum speeds of 70Mbps and an average coverage range of 5-8 kilometres. However, the longer the distance between the antenna and the CPE, the lower the transmission speed. WiMax is also a shared medium. The more active users, the less bandwidth is available.

3.2 FTTN+VDSL

Like all DSL variants, the data throughput performance of VDSL and VDSL2 is a function of the distance between the DSLAM and the end-user: the further the distance, the greater the performance deterioration.

Asymmetrical VDSL, which was standardised by the ITU in June 2004 (G.993.1), offers a theoretical maximum downstream speed of 52Mbps (2Mbps upstream), but attaining that performance level would only be possible at distances of less than 300 metres between the remote DSLAM and the end-user. For distances in excess of 300 metres, VDSL performance rapidly deteriorates. Between 1km and 1.5km, VDSL offers downstream speeds of around 15Mbps, which is similar to the performance level of ADSL2+ at that distance.

3.3 FTTN+VDSL2

Symmetrical VDSL2, whose standard specifications were recommended by the ITU in May 2005 (ITU G.993.2), offers a better throughput performance. Using a greater amount of frequency spectrum over the copper – 30MHz as opposed to 12MHz for VDSL – VDSL2 can offer a maximum theoretical symmetrical speed of 100Mbps. But again, this would only be possible if the DSLAM was located very near to the end-user (under 300 metres). At 1km, VDSL2 throughput drops to around 25Mbps.

The topology of the existing copper network is therefore a crucial factor in determining how suitable FTTN+VDSL/VDSL2 deployment is. In Germany, the average distance between the end-user and the street cabinet in urban areas is 300 metres; in France, the average distance is 800 metres. Deutsche Telekom is pursuing a FTTN+VDSL2 strategy and France Telecom intends to roll out FTTH.

However, there is a 'long reach' version of VDSL, which uses the 12MHz frequency band. Its proponents say that this can deliver around 35Mbps downstream at distances of 1km, which would allow operators to provide faster speeds to more customers. The flexibility of VDSL2 to function in different bandwidths is specified in the G.993.2 recommendation. In fact, to cater for different bandplan requirements in different regional markets, as well as different applications (such

as central office, remote DSLAM, digital loop carrier and MDU connections), the VDSL2 standard specifies eight different configuration profiles based on the parameters of power and frequency range. VDSL2 is designed to be a truly universal standard.

It is also backwards compatible with ADSL2+. VDSL2 line cards in the DSLAM can be inserted and still serve ADSL2+ modems. The ADSL2+ modems can then be upgraded to VDSL2 when necessary – if the customer is eligible for the faster service – which makes rollout faster and easier for the operator. But with this amount of flexibility comes complexity. The ITU G.993.2 recommendation is 221 pages long and vendor interoperability will probably remain a VDSL2 issue over the next 12-24 months. Even so, this hasn't stopped major network operators, such as AT&T, Deutsche Telekom, Belgacom and KPN, pushing ahead with their own FTTN+VDSL2 implementations.

VDSL, due to its less attractive performance characteristics than VDSL2, is unlikely to gain momentum among operators pursuing FTTN strategies.

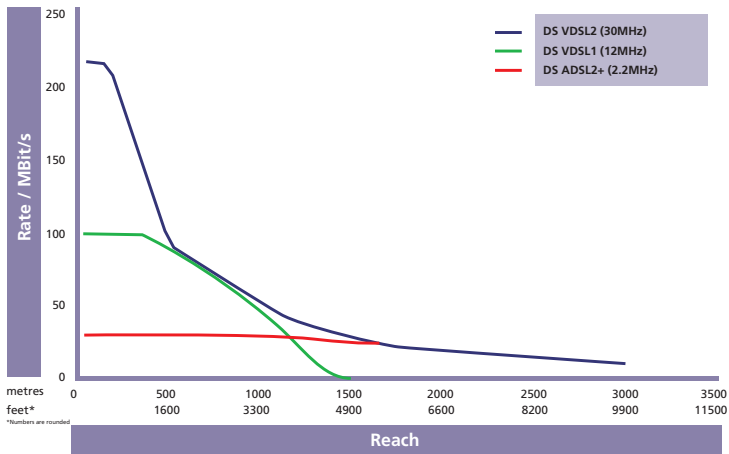


Figure 3.1: Performance characteristics of ADSL2+, VDSL and VDSL2

Source: Infineon

3.4 FTTN+VDSL/VDSL2 versus FTTH/FTTB

Advantages

- Faster time-to-market than FTTH/FTTB to deliver higher-speed services than ADSL2+. No need for operators to negotiate rights of way to lay fibre between intermediate distribution point and the home/building; no need to negotiate with landlords for fibre access into the building.
- Less upfront capex required than FTTH/FTTB through the re-use of existing copper resources; no need for costly civil engineering works between the home/building and the intermediate distribution point.

Disadvantages

- FTTN+VDSL/VDSL2's higher bandwidth speeds are only available to a small percentage of operators' customers compared to FTTH/FTTB architectures. According to IDATE, if all remote DSLAMs in France were equipped with VDSL2, less than 10% of the population would be eligible for 50Mbps. Similar coverage assumptions can be made about other markets, says IDATE.
- FTTN operators have higher operational expenditure (opex) than PON operators through the need to manage multiple small nodes within the network¹¹.
- The GPON standard has a 20km reach between the ONU and the OLT, which offers the operator the prospect of central office consolidation and a further reduction in opex. This option is not available to FTTN operators.

3.5 Enhanced xDSL cables

The performance of both ADSL2+ and VDSL2, as outlined above, is not necessarily set in stone. Through 'enhanced' xDSL copper cabling, which has been available in the market since early 2006, dramatic improvements in either distance or bandwidth can be achieved with a minimal capex outlay. (If an operator needed to repair degraded copper plant, anyway, the extra cost of replacement with enhanced cabling would be negligible.)

According to Nexans, an ADSL2+ operator could provide 50% more services to customers located within a 2.5km copper loop radius from the central office using enhanced DSL copper cable. Or, if the operator preferred, the bandwidth reach of ADSL2+ could be extended by some 40%.

¹¹ Verizon expects to make annual opex savings of US\$1 bn by 2010 through its FTTH network

4 Factors affecting FTTx deployment

4.1 Overview

When operators weigh up their FTTx architecture options, a number of factors will have to be taken into account. These include what assumptions are made about customers' bandwidth requirements; the topology of the existing legacy network; the level of competition from cable operators; the cost of laying fibre to the node compared with running it the way to the home or building; population density, and the regulatory environment.

For the purposes of the The FTTx Mini-Guide, we will focus on three key areas: customers' bandwidth requirements, cost per FTTx subscriber and regulation.

4.2 Bandwidth requirements

4.2.1 Overview

What are the applications and services that will justify investment in either a FTTN or a FTTH/FTTB architecture? Moreover, *when* do operators need to have their chosen FTTx architectures in place, assuming that the level of customer demand for bandwidth increases beyond the capability of copper-based DSL connections that run between the central office and the end-user?

These are key questions for operators as they consider the various fibre access investment options before them. Unfortunately, there are no hard and fast answers.

Arguably, the overwhelming majority of consumers do not need – at least for the time being – as much as 100Mbps. That said, operators may be forced to provision more bandwidth than consumers practically require due to the presence of 'speed competition' in the market rather than 'service competition'. But as speed competition represents a sub-optimal business model – high investment for low returns – a key challenge for FTTx operators will be to develop and market services that can bring a significant return on their broadband investment.

The good news for operators, provided they can get their marketing strategies right, is that services based on high-speed access networks can significantly boost monthly ARPU. According to Nexans, 'first generation' services comprising analogue voice typically produced monthly ARPU in the order of €20-25. With 'second generation' services – a combination of Internet access and analogue voice – monthly ARPU rises to €25-30. With next-generation triple-play services – comprising fast Internet, VoD and HDTV – Nexans believes that operators' monthly ARPU levels can jump to the €30-50 band.

4.2.2 The 'bandwidth-hungry' contenders

High-definition TV (HDTV)

Many industry analysts see HDTV as a 'must-have' ingredient in operators' triple-play offerings. Although the availability of HD channels is much more widespread in the US, South Korea and Japan than other parts of the world, the general consensus is that other developed markets will soon catch up and operators without HDTV will be competitively disadvantaged.

How much bandwidth HDTV will require is a moot point. The latest generation of video compression technology –MPEG-4 – is widely accepted as being able to deliver pristine HDTV at between 10-12Mbps. But Harmonic, a US-based provider of IP delivery systems, says it can deliver the same high quality HDTV at 8Mbps – and a lower quality version at 4Mbps – using MPEG-4. A standard definition (SD) TV channel, using MPEG-4, would need 1.5Mbps. Using these assumptions, Harmonic argues that operators could offer TV and High-Speed Internet (HSI) access services for 20Mbps (Figure 4.1).

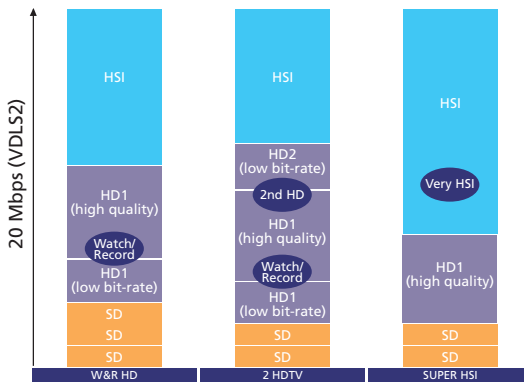


Figure 4.1: Different TV and HSI service scenarios using 20Mbps

Source: Harmonic

It is not yet clear, though, how keen content providers and consumers will be on the delivery of MPEG-4 content to larger TV screens. Video compression can noticeably affect picture quality for larger screen sizes (above 40 inches). This could be a problem for operators who base their FTTx choice on MPEG-4 yet compete in markets where the popularity of bigger screen TVs increase.

Web 2.0

Web 2.0 is an industry term that alludes to using the Internet as a means for sharing user-generated information and creating virtual communities. YouTube, the most popular of the video-sharing sites, reported at the time of its acquisition by Google (October 2006) that users – on a daily basis – were downloading 100 million videos from its site and uploading 60 million. For operators seeking to launch interactive Web 2.0 services of their own, they would need to be able to ramp up bandwidth availability on both the downstream and the upstream as and when demand arose.

Peer-to-peer (P2P) traffic

The volume of P2P traffic, where users send files (audio and video) to each other over the Internet, is increasing rapidly. According to IDATE, P2P now represents 65% of Internet traffic and about 80% of upstream capacity.

From an operator's point of view, P2P is not directly beneficial. It is difficult to generate revenue from it and the transport costs can be high. However, if consumers and businesses perceive P2P applications as valuable – businesses, for example, could use P2P to improve communication between partners and customers – then operators who offer higher bandwidth throughput, particularly on the upstream, should be at a competitive advantage.

Although P2P traffic is unlikely to be a direct source of increased revenue, an operator who can facilitate P2P traffic with a higher quality of service than its competitors should have a better chance of increasing revenue indirectly through reducing churn and attracting new customers. The continued rise of P2P traffic raises serious questions about the usefulness of asymmetrical DSL (ADSL) technology in the short- and mid-term. Conversely, the FTTx architectures that can provide greater upstream capacity become more valuable.

Business applications

Videoconferencing and teleworking, coupled with the desire to have increasingly fast remote access to corporate LAN resources, may well be drivers for FTTx investment. However, not all industry sectors will have the same level of demand to transfer large files and not all businesses will have the same level of desire (or need) to initiate video-conferencing sessions. To justify FTTx investment on the basis of serving the business customer, the operator would have to ensure there was a sufficient density of bandwidth-hungry businesses and/or remote workers within the footprint of a FTTB or FTTN architecture.

Public services

In FTTH/FTTB city projects where local government is involved, new public services that can be delivered over fibre are often cited to help justify the broadband investment. In the FTTH projects of Amsterdam and Vienna, local government representatives talk of e-health care via videoconferencing, as well as the remote monitoring and diagnosis of patients' key health measurements – particularly those of the homebound and elderly – as examples of how high-speed connections can help the local authority function more effectively and cost-efficiently.

4.3 Cost per FTTx subscriber

4.3.1 Overview

As the level of spending on high-speed services is difficult to predict, so it is unclear how low the cost per FTTx subscriber needs to be before an attractive return on investment can be achieved. The good news for operators is that costs are coming down. Three years ago, the average cost per FTTH subscriber in urban areas in the US was over US\$2,000 but it is now down to sub-US\$1,000 levels. Verizon reports that at the end of 2005 the cost per FTTP (Fibre-to-the-Premise) was US\$1,021; by the end of 2006 that had fallen to US\$850.

FTTx subscriber costs could even be lower in urban areas where there is a high density of MDUs (multi-dwelling units), such as in Japan and South Korea. The cost reduction can be explained by a combination of vendor consolidation (leading to cheaper components) and 'smarter' civil works. Comprising the laying of outdoor cable – either through trenching or by using existing ducts – civil works is the most costly aspect of FTTH rollout. According to IDATE, up to 80% of the total capex required for FTTH rollout on a greenfield site can be soaked up by outside plant construction.

4.3.2 Cost-reduction methods

There are a number of ways to reduce outside fibre plant construction. The use of aerial fibre connections – a method used by NTT and Verizon – is one way, while the use of existing underground infrastructure (such as the sewer or underground railway system) is another.

The sharing of existing ducts by different operators is another option. The use of existing ducts has been made easier through the technique of 'blowing' micro ducts through loose duct tubes, which, in turn, can have strands of fibre blown through them to support 32-user and 64-user PON configurations. According to Nexans, it has improved blowing performance to the extent that it is now possible to install optical fibre at the rate of 4km per hour – or 15 minutes per kilometer – over segments of 2km. Moreover, through its own blown fibre cable assemblies, Nexans can provide fibre installation on an on-demand basis once the micro ducts have been laid. This enables operators to ramp up capex in line with subscriber sign-up revenue.

Alcatel-Lucent calculates that FTTH rollout costs can be cut by up to a half if already-laid ducts are available as opposed to building an entirely new outside fibre plant from scratch (Figure 4.2).

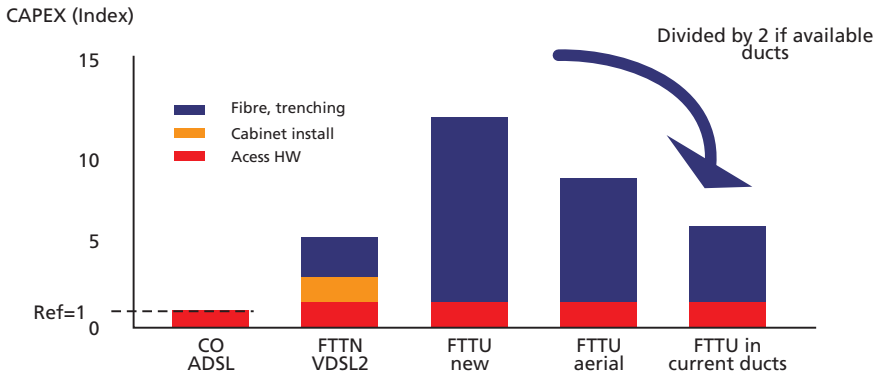


Figure 4.2: Capex comparison for FTTx

Source: Alcatel

Indoor cabling can also be an expensive item on the FTTH list, particularly for PON operators looking to deliver digital TV and IPTV. Traditionally, PON operators haven't been able to take advantage of in-home coaxial cable and have needed to send engineers to install CAT5 cable.

In November 2006, however, Hitachi Telecom (USA) announced the availability of what it claims to be the world's first GPON ONT that is fully compliant with the MoCA (Multimedia over Coax Alliance) standard. This allows GPON vendors to deliver Digital TV/IPTV over existing co-axial cable. According to Hitachi Telecom, this will cut engineers' installation time by three to four hours.

4.4 The regulatory environment

4.4.1 Overview

While government-backed initiatives have helped stimulate FTTx investment in Japan and South Korea, regulatory developments in the US have served to boost the market.

In October 2004, the Federal Communications Commission relieved incumbents from unbundling requirements on their Fibre-to-the-Curb (FTTC) loops, where fibre is extended within 500 feet of a customer's premises. As a result, the US

incumbents could then invest in FTTx architectures safe in the knowledge that competitors wouldn't be able to 'piggy-back' on their networks, which would make an attractive ROI much harder to achieve. The FCC ruling has had a dramatic effect on the number of FTTH subscribers and the number of 'Homes/Premises Passed'¹² in the US. In mid-2004, there were 78,000 FTTH connections and 189,000 Homes Passed. By the end of 2006, those numbers had increased to over one million and over six million respectively.

In Europe, uncertainty over regulation has been a major contributory factor in holding back FTTx investment.

4.4.2 EU Regulatory Framework

In 2006, the European Commission (EC) initiated a public consultation process to review the EU Regulatory Framework¹³ for electric communications networks and services. At the end of the consultation period – scheduled for the first half of 2007 – the EC is to recommend the relevant retail and wholesale markets that should be subject to so-called *ex ante* regulation.

A market is classified as suitable for *ex ante* regulatory intervention if there is no prospect of effective competition emerging in the absence of regulation. This would usually be due to the presence of an operator, deemed to have significant market power (SMP) status, having the ability to raise barriers to stop other operators entering that market. The *ex ante* regulation takes the form of imposing a set of regulatory obligations on the SMP operator to prevent it from using its power to retain a monopoly position. These obligations include unbundling fibre-based local loops and to wholesale all retail products to competitors at prices set by the national regulatory authority (NRA).

The key regulatory question for operators in Europe is whether or not their high-speed access networks will be subject to *ex ante* regulation. They argue that FTTH, as well as FTTN+VDSL, represents a new or 'emerging' market and so should be immune from regulatory intervention. By having a so-called 'regulatory holiday' – free from *ex ante* obligations – operators say they will have more incentive to invest in FTTx. When it publishes its final recommendations in 2007, it seems unlikely that the EC will condone regulatory holidays for FTTN+VDSL networks. Viviane Reding, Information Society and Media Commissioner at the EC, has repeatedly stated through the review process that she considers the services running over FTTN+VDSL to be similar to services already in the market using other DSL technologies. Is it less clear whether FTTH will be granted 'emerging market' status or not.

¹² Refers to the number of residential and business premises to which an operator can deliver FTTH access within the operator's standard activation period

¹³ The Regulatory Framework comprises five Directives. The Access Directive, which governs the access to and interconnection of electronic communications networks and services, is the one most relevant to FTTx regulation

In the meantime, Deutsche Telekom has said it is holding back on its €3.3 bn plan to roll out FTTN+VDSL2 to 50 cities in Germany until it gets the regulatory certainty it is seeking. But fears about regulation need not necessarily be an FTTx showstopper. KPN, the incumbent operator in the Netherlands, is pushing ahead with its FTTN+VDSL2 plans, despite being forced by the NRA to open up its network to competitors. The threat of competition from Dutch cable operators has outweighed the incumbent's regulatory concerns.

4.4.3 The 'horizontally-integrated' business model

Although EC's Reding favours infrastructure-based competition to stimulate FTTx innovation and take-up, where that is not possible – perhaps through a lack of sufficient capital or available underground infrastructure – she has proposed as a possible 'remedy' to infrastructure monopolies the idea of an enforced 'functional separation' between the incumbent's 'passive' and 'active' layers.

In this context, the 'passive' layer includes such things as trenches, ducts and dark fibre; the 'active' layer refers to managing the network. The network operator, in this model, would then wholesale capacity to different service providers who would then be responsible for retailing services. As a substitute for infrastructure-based competition, this arrangement is designed to stimulate service competition over one infrastructure and is sometimes referred to as the horizontally-integrated business model. The vertically-integrated model is where the operator is responsible for both the passive and active layers.

The FTTH projects in Amsterdam and Vienna have already adopted the horizontally-integrated model as a way to stimulate broadband service innovation and take-up in the absence of FTTH investment by the national incumbent.

5 FTTx deployment status

5.1 Europe

According to IDATE, the number of FTTx subscribers in EU 18 (EU 15 + Norway + Iceland + Switzerland) was a mere 646,570 as of June 2005 with around 2.51 million homes/buildings passed. Moreover, 97% of these FTTx subscribers are concentrated in five countries (Sweden, Italy, Denmark, the Netherlands and Norway) where competition from alternative and cable operators is strongest.

Although Deutsche Telekom embarked on an ambitious FTTN+VDSL2 project in 2006 to connect 50 cities, that project has been subsequently put on hold due to regulatory uncertainty (see 4.4.2). By the end of 2006, Deutsche Telekom had rolled out FTTN+VDSL2 in ten cities.

For commercial FTTH deployment, municipalities, power utilities and alternative operators have been largely responsible for initiating new projects. One of the most ambitious of these was announced by the Iliad Group in September 2006, which plans to invest €1 bn in a FTTH network in Paris and other French cities with the aim of passing 10 million French customers by 2012. In response, France Telecom announced in December 2006 that it intends to connect between 150,000 and 200,000 customers with a GPON-based FTTH architecture by the end of 2008. Its aim is to offer symmetrical speeds of up to 100Mbps to each subscriber.

5.2 North America

Although the number of FTTH connections is growing fast in North America, primarily due to the favourable regulatory environment for the US RBOCs (see 4.4.1), they still represent less than 1% of total household connections.

The biggest FTTH project in the region is Verizon in the US. With an investment of US\$23 bn, it plans to pass 18 million premises with its fibre network by the end of 2010. The operator says it is on target to pass six million premises by the end of 2006.

AT&T, which has opted for FTTN+VDSL2 architecture (only FTTH for greenfield sites) is aiming to pass nearly 19 million households as part of the initial deployment of its Project Lightspeed by the end of 2008. According to the FTTH Council North America, AT&T is currently passing 0.5 million homes per year with its FTTN+VDSL2 architecture.

5.3 Asia

FTTx in Asia is being led by Japan and South Korea. Japan's NTT, responsible for the world's largest commercial deployment of FTTH, had over six million FTTH subscribers at the end of 2006 via its two subsidiaries, NTT West and NTT East. As a sign of increased FTTH momentum, the number of net FTTH subscriber gains started to exceed the number of net ADSL gains for both NTT West and NTT East in March 2006. By the end of 2007, NTT expects the number of FTTH subscribers to surpass the number of ADSL subscribers, which stood at around 14 million at the end of 2006 (but steadily falling due to FTTH competition). The aim for NTT is to have 30 million FTTH subscribers by the end of 2010.

In South Korea, the country's two main fixed-line operators – Korea Telekom (KT) and Hanaro Telecom – are pushing ahead with FTTx+VDSL and FTTx+Ethernet LAN (fibre-to-the-building with Ethernet LAN distribution, via VDSL, to the apartments). According to IDATE, KT had 627,000 Ethernet LAN subscribers and two million VDSL subscribers by mid-2005. Hanaro had passed 4.6 million homes either by VDSL or Ethernet LAN by the same time. Korea Telekom (KT) has also trialed WDM-PON technology using equipment from Novera. Commercial services have so far been limited to around 2,000 households in newly-constructed apartment buildings.

The FTTx Mini-Guide

Author: Ken Wieland

First Edition
February 2007



www.telecommagazine.com



www.nexans.com