MIGRATING TO THE UNCERTAIN

Carsten Storbeck, ADC KRONE

Most operators agree they must move towards a single technology Next Generation Network (NGN), based on Internet Protocol (IP) which can provide a ubiquitous bit-transport system for all network services. But without a sound strategy to deliver NGN IP to the millions of users through the Access Network this will be of little use, warns Carsten Storbeck; there are some cardinal rules which must be followed.

Most operators agree they must move towards an ideal single technology network, based on IP (Internet Protocol), which can provide a ubiquitous bit transport system for all network services.

INTRODUCTION: EXPECTATION VERSUS EXECUTION

Over the last few years broadband has become part of everyday life in most countries worldwide. Users now expect at least 0.5Mbit/s, maybe 8Mbit/s and in some countries they enjoy 100Mbit/s into their homes. Digital Subscriber Loop (xDSL) broadband has become a standard service and more and more bandwidth is becoming necessary, both in the core and access networks, to satisfy demand.

As a result, most operators concur they must head towards an IP-based single technology network which can provide a ubiquitous bit-transport system for all network services. For many operators, the logical first step to all-IP is to update the trunk or core network, involving a wholesale change away from time division multiplexing (TDM) digital main switching centres and from transmission systems such as Synchronous Digital Hierarchy/Synchronous Optical Networking (SDH/SONET).

This represents a major challenge, but it is probably fair to say the migration to new access networks is an even more demanding proposition and the main subject of this paper. By their very nature, access networks pose more complex questions for operators, such as how to provide critical physical flexibility, which is required to cater for their customers' needs, as well as making the right decisions about the many potential techniques for implementing them.

As we have entered the broadband era, voice services have ceased to be profitable for many network providers due to the compound effect of de-regulation, competition and of owning legacy networks which use multiple and mixed technologies to deliver today's services. These networks are no longer efficient enough to provide the low operating cost-base essential for profitability in a commoditised market. From a revenue perspective, network operators want to be able to offer value added services such as Triple Play (combined voice, data and High Definition (HD) video) requiring up to 55Mbit/s to each home.

While the move to all-IP is without doubt the way to achieve this, each operator must find a unique migration strategy to move from its current multi-technology legacy network towards its ultimate all-IP network goal. There are a number of different high-level strategic approaches, but each network will be different and unique – and practicality demands that this migration will take place in stages over a number of years.

ALL CHANGE

The degree of change needed from current mixed-technology to all-IP is enormous. Core or trunk network, Central Office (CO) and access network must all be replaced with IP-based equipment. It is as massive a change as 20 years ago when COs moved from step-by-step and crossbar to TDM digital and transmission networks moved from frequency division multiplexing analogue to SDH/SONET.

The ideal technology migration for each network provider is going to be different. The economic landscape in which each operates will also be different as will the difficulty in predicting development of their market. All of these factors will combine to dictate the overall migration strategy and the tactics of implementation.

It is interesting to note that many step-by-step CO exchanges were in service for 50 years, some as many as 100 years. Crossbar and TDM digital had a service life of perhaps 20 years. Yet the routers, switches and Digital Subscriber Loop Access Multiplexers (DSLAMs) of Next Generation Networks (NGNs) may have service lives as little as five to seven years.

Possibly the only thing that is certain in the whole NGN landscape is that it will be constantly changing.

> By their very nature, access networks pose more complex questions for operators, such as how to provide critical physical flexibility, which is required to cater for their customers' needs.

NOT PLANNING FOR CHANGE

For decades, flexibility, cable management and cross-connection capability at all points have been the watchwords of the telephony engineer who grew up in an environment where the only constant was change. Sadly this sage experience has not always been applied to new telecommunications projects – with expensive consequences.

An example from recent history can be found in the early mobile networks. Equipment vendors and radio engineers, who had not grown up with these 'Telco' mantras, together with their customers, believed they could make significant capital and space savings by employing direct connection techniques and not deploying distribution frames and cross-connects. In recent years, however, the pressure to increase traffic volumes has meant that they need to downsize cells and reduce coverage areas to achieve this. Sadly, because they did not plan for change and did not deploy the facilities that make change easy, they are now suffering significant network downtime and massive downstream costs in order to reconfigure their networks. These are costs that can be counted both in terms of cash and customer dissatisfaction.

PROMISES, EXPECTATIONS, PROBLEMS

Whichever strategic route a network provider takes (this paper covers the main ones later), serious service-affecting pitfalls await.

It generally happens like this: Technology advances make innovation possible. The company needs to gain competitive advantage in the market place. Senior management makes promises of new services to customers and revenue streams to stakeholders. The strategy is set but senior management play down or ignore the concerns and wisdom of the old-hand telecommunications engineers who they see as fussing over the minute (but essential) details of implementation. Over time, however, service-affecting problems emerge, increasing costs, reducing profits and upsetting customers.

The devil, as they say, is in the detail.

RELIABLE, RESILIENT

One factor behind this phenomenon is that, with the move from conventional telephony to IP, the supplier base is now largely Information Technology (IT) companies such as Ethernet switch and router manufacturers. Like the mobile network manufacturers referenced above, they do not have the long history of the tried and tested 'Telco' way of doing things. These are ways that have for many years delivered exceptional levels of network reliability – many orders of magnitude higher than commonplace in the IT industry.

This is where companies with decades of experience, like my own, working at the detailed level in core or trunk networks, CO and access networks are invaluable to network operators and IT equipment manufacturers wanting to build NGNs that are robust, reliable and resilient, no matter how much change is required during their operating life.

STRATEGIC AIMS, TACTICAL STEPS

For decades, flexibility, cable management and cross-connection capability at all points have been the watchwords of the telephony engineer. Sadly this sage experience has not always been applied to new telecommunications projects – with expensive consequences

There are many different ways of migrating towards an all-IP network. In this article we look at the key access network stages/options as well as well as the various CO/core network options.

- Legacy copper network;
- Fibre to the Node (FTTN) – with xDSL overlay. Retaining copper in the first mile, some fibre to larger buildings, TDM CO retained for voice services, and DSLAMs in the outside plant;
- FTTN – with Multi-Service Access Nodes (MSANs) in the outside plant. No CO, copper in the first mile, and some fibre to large buildings;
- Fibre to the Curb (FTTC; 'Ethernet all the way'). Ethernet over copper to the home, with no CO and some fibre to larger buildings;
- Fibre to the Premises (FTTP) – Passive Optical Network (PON). IP-over-fibre PON all the way to every home and building using intermediate passive optical splitters to share backhaul fibre bandwidth;

- FTTP – Point-to-Point. IP-over-fibre all the way to every home and building with dedicated fibres coming all the way from the CO or PoP building. Bandwidth is not shared in the access network;
- Core network and CO considerations.

HOW FAST IS FAST ENOUGH?

Figure 1 '… and still the Queen kept crying `Faster! Faster!' but Alice felt she could not go faster, though she had not breath left to say so'. *Alice through the Looking Glass*. Lewis Caroll

One of the biggest unknowns in migrating to the all-IP NGN is 'how much band width is enough?' – 50Mbit/s, 80Mbit/s, 100Mbit/s, 1Gbit/s or more?

Current MPEG4 HDTV requires about 9-10Mbit/s – so a 55Mbit/s Very High Speed Digital Subscriber Loop 2 (VDSL2) will allow four concurrent HDTV channels or a mix of HDTV, voice and data.

Already in a number of countries, home-owners are enjoying data rates of 100Mbit/s. The truth is none of us really knows, but chances are very high that even the 55Mbit/s of VDSL2 (requiring active electronics to be less than 1km from the user) is only an interim solution.

True, DSLAM ports can be 'bonded' to double the effective data rate to 100Mbit/s; this however reduces the capacity of a DSLAM from, say, 192 customers to 96 and requires two copper pairs to each customer. It is feasible but it is not elegant and probably only worthy as a short term solution.

For the network architect it is a major guessing game. What bandwidth demands will developments in active equipment permit in coming decades? We all 'feel' that ever increasing bandwidth is needed – but, with decreasing revenue per Mbit/s, can a business case be made to support the funding of this ever higher bandwidth technology? And, will the upgrade (to achieve the next step(s) of higher bandwidth) be the simple swapping out of a VDSL2 DSLAM card or optical line terminal to some new version that will work over the same copper or fibre access network plant, or will another change to the architecture be necessary?

One thing becomes very clear. We don't know what will be the technology after next, let alone the one after that. The one thing that conscientious network architects can do (whether deploying FTTN or FTTP) is to deploy as much flexibility and 'easily adjustable connectivity' as they can at every stage of the build-out so that when the inevitable next change comes along, its deployment is as painless as practically possible.

LEGACY NETWORK

The majority of public networks have the exact same copper distribution network they have had for 50 to 100 years. Technological progress has allowed operators to deliver integrated services digital network (ISDN) or Plain Old Telephone Service (POTS) and xDSL broadband over this network to an amazing 55Mbit/s close to the CO, but only a few Mbit/s on lines of 3km and over. Some existing lines can be up to 12km from the CO to the customer.

This copper distribution network is no longer capable of upgrade to faster speeds or to all-IP. As a CO to end-user entity it has reached the end of its life.

With technology changing so fast, there are many and changing options for the network architect to consider - as we discuss in the following sections.

PARTIAL FTTN: XDSL OVERLAY

For many network operators, replacing the entire existing copper access network and digging fibre to every home simply cannot be cost justified.

However, the technology restraints of higher-speed broadband technologies dictate that DSLAMs for VDSL or VDSL2 must be within one kilometre of the user.

So while customers within a one kilometre Radius of the CO can continue to be served by CO-housed DSLAMs, for users further than this distance, there is no option other than to move the DSLAM electronics into the harsh outside plant (OSP) environment.

In this strategy, the legacy TDM CO switch continues to provide POTS and ISDN service and all existing xDSL customers can continue with their current xDSL service from the CO DSLAMs through splitters at the CO.

VDSL DSLAMs, with fibre backhaul to the CO must be installed – typically collocated with existing copper distribution cabinets. VDSL splitters also have to be located here. When customers require high speed (for example for Triple Play), these services can be jumpered into service at the DSLAM/cross-connect OSP cabinet from which they are routed to the home or business over the existing copper distribution plant.

If additional backhaul fibre capacity is installed into the OSP DSLAM / crossconnect cabinet, and a small fibre crossconnect installed, it becomes possible to offer fibre to the building (FTTB) services to larger customers, large buildings or campuses. Where the business case warrants it, DSLAMs can even be installed within office blocks or multi-dwelling units.

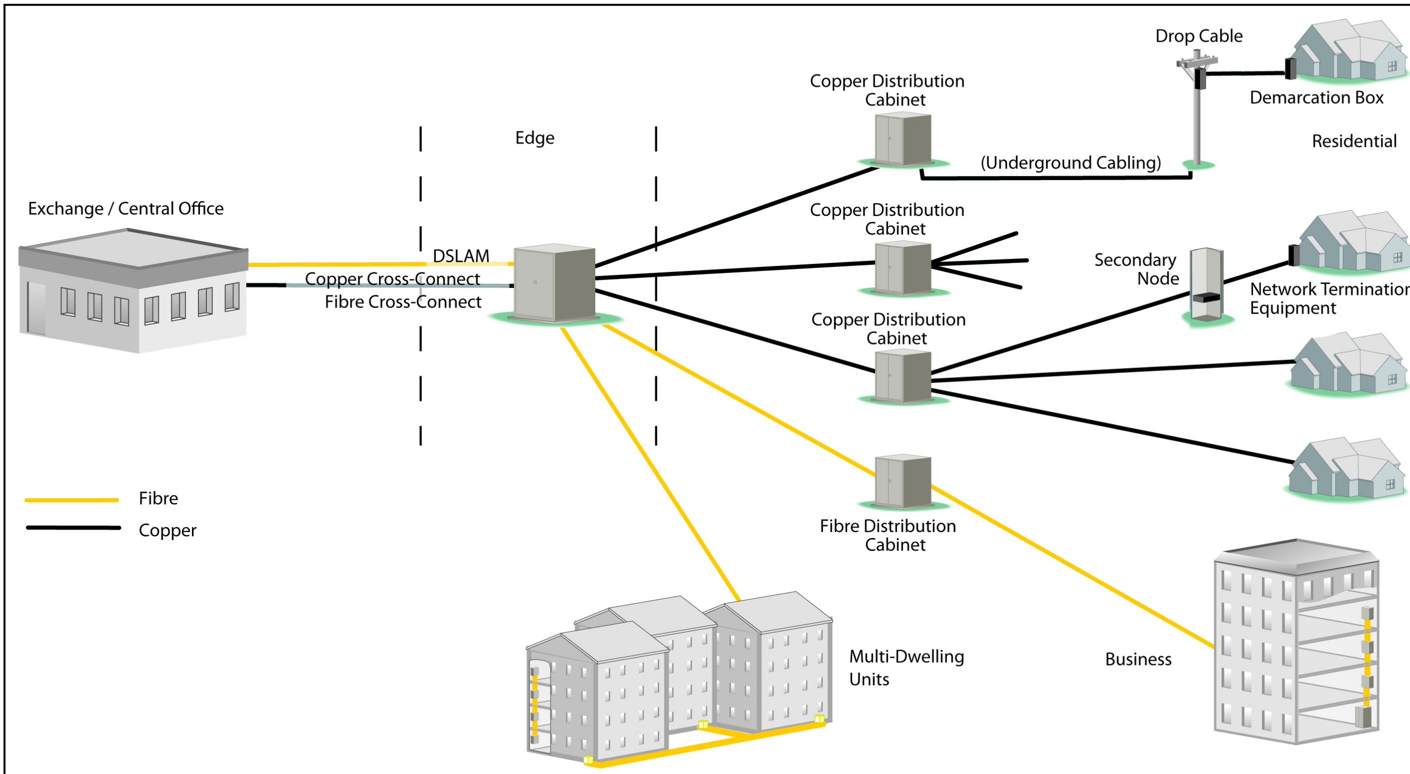

Figure 2 Partial FTTN: xDSL overlay

ADVANTAGES

This is the lowest investment model for NGN service delivery. It enables the copper distribution network to be retained in service by simply overlaying VDSL DSLAMs in the OSP. The overlay of fibre distribution network to these OSP DSLAMs also enables FTTB services to large customers or large building/campuses.

DISADVANTAGES

Although this delivers up to 55Mbit/s to each home/business – which can be presented as IP/Ethernet – the network itself remains very much mixed technology with a TDM CO, IP/Ethernet over fibre to the DSLAM and xDSL over copper to the home/ business. All of these mixed technologies and the need for effectively multiple networks leads to higher operating and maintenance costs compared to an 'any service' all-IP converged bit-transport network.

Thousands of electronic equipment cabinets must be deployed in the OSP environment.

CHALLENGES

- Deploying active electronics in the harsh OSP environment;
- Splitters, fibre and copper cross-connects need to be installed in the smallest possible space in the OSP because the space available for street furniture like OSP cabinets is severely limited and the active electronics is bulky. Thus any space taken for these reduce the space available for the active equipment;
- The expensive and lengthy task of deploying fibre in the OSP from CO to OSP DSLAM/cross-connect cabinet;
- Challenge of splicing and hardened connectorisation in OSP cross-connects for flexibility – although with the correct products OSP connectorisation need no longer be an issue;
- Fibre termination, cross-connect and management into building (FTTB);
- Electrical power feeds to thousands, possibly tens of thousands, of OSP cabinets. There are lots of region-specific issues - such as certification of equipment for connection to the power utility, different rules on how the power equipment has to be physically separated from the technician accessible space, whether the power has to be metered (in which case access is needed for the utility meter reading personnel) or charging by maximum-demand.

For the network architect it is a major guessing game. What bandwidth demands will developments in active equipment permit in coming decades?

FTTN: MULTI SERVICE ACCESS NODES

An alternate approach to xDSL overlay is to retain the 'first mile' copper distribution network, but to move directly to all-IP in the core network.

FTTN is the main technology, with the old TDM CO completely de-commissioned and everything network-side of the node is IP-over-fibre.

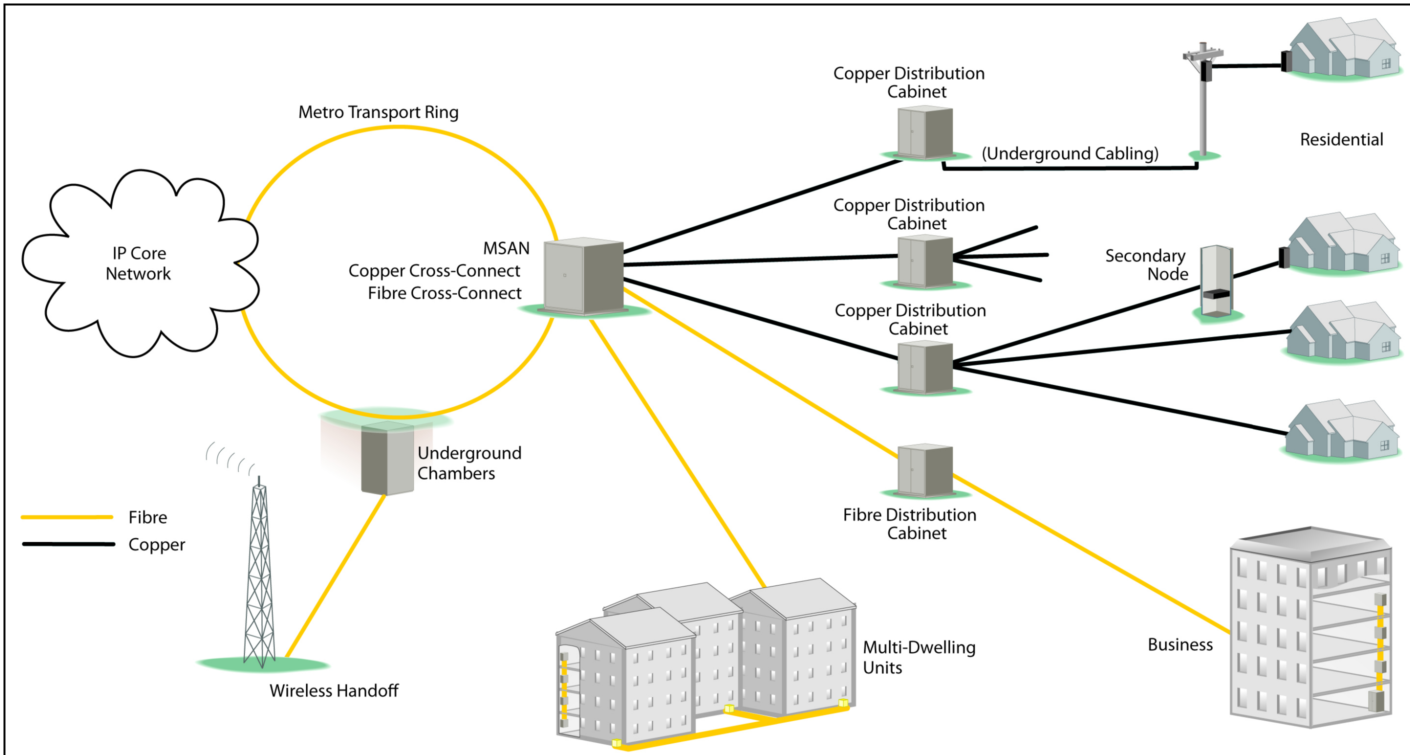

Figure 3 FTTN: Multi service access nodes

The OSP node has to be located within one kilometre of the user to enable 55Mbit/s Triple Play services to be delivered. In this strategy, the active electronics in the OSP is called an MSAN. Here, not only are xDSL/ VDSL DSLAMs, but also cards to interface from IP in the core network to POTS and ISDN services. The MSAN would ideally be backhauled by an IP fibre ring to provide route diversity and fail-over protection.

If sufficient fibre capacity is provided in the backhaul feeder cables and a small amount of fibre cross-connect in the OSP cabinet, it becomes possible to provide FTTB to the larger customers or multiple occupation offices and dwellings.

ADVANTAGES

- This is a much more ambitious strategy than xDSL overlay and moves the network operator far closer to the ultimate goal of fibre to every premises;
- The entire core network has to be upgraded to all-IP and the major part of the access network becomes IP-over-fibre. Only the first mile remains POTS/xDSL over existing copper. This defers the massive cost of digging-in fibre to every home and business.

DISADVANTAGES

Current VDSL technology limits the deliverable bandwidth of Triple Play over copper to around 55Mbit/s at one kilometre. Customers of competing networks with fibre-to-the-home or FTTB may be offered 100Mbit/s or even Gigabit Ethernet service.

CHALLENGES

- Upgrading the entire core network to all-IP;
- Deploying and maintaining active electronics in the harsh OSP environment;
- Splitters, fibre and copper crossconnects need to be installed in the smallest possible space in the OSP;
- Deploying fibre in the OSP from CO to thousands of OSP DSLAM/crossconnect cabinet;
- Challenge of splicing and hardened connectorisation in OSP cross-connects for flexibility;
- Fibre termination, cross-connect and management into building (FTTB);
- Electrical power feeds to thousands of OSP cabinets.

For many network operators, replacing the entire existing copper access network and digging fibre to every home simply cannot be cost justified

CHOOSING BETWEEN FTTP (DSLAM OVERLAY) AND FTTN (MSAN)

Before finalising the FTTP or FTTN decision, network architects should consider the option of merely providing DSLAMs at the node as an xDSL overlay to give a short term fix to the need to offer 20-55Mbit/s services immediately and, in so doing, perhaps stave off competition from the cable companies / multiple service operators.

FTTN (xDSL overlay) is relatively inexpensive in that it achieves fairly rapid ability to provide service without the cost of replacing the copper in the first mile – and by only having to provide DSLAM equipment for a percentage of user lines. (Voice and lower speed asymmetric DSL (ADSL) services can continue to be provided directly from the TDM switch and ADSL DSLAMs back to the CO.)

FTTN (xDSL overlay) does however require fibre to be dug out from the CO to each node and thought should be given at this stage to the economics of laying sufficient fibre to pave the way for migration to either FTTN (MSAN) or FTTP (building/ home).

FTTN (MSAN), on the other hand, is a more expensive option requiring the replacement of the TDM CO switch and the co-located DSLAMs together with the provision of an all-IP core network right up to the nodes. Much more electronics is needed at each node – since all customer services are provided from here whether they are analogue POTS/ISDN or POTS/ISDN+xDSL or all-IP such as VDSL or its successors.

FTTN (MSAN) with its all-IP backhaul and core network should be planned and deployed with ease of migration to FTTP in mind – ultimately replacing the copper first mile with fibre, replacing all the active equipment with passive splitters for a PON FTTP architecture. Point to Point FTTP would be a more difficult final option as the backhaul for both MSAN and PON relies on fibre 'concentration' at the node, and there is not likely to be enough fibre backhaul capacity from the node to the CO or PoP.

FTTC: ETHERNET OVER PASSIVE OPTIC NETWORK

Some network operators have deployed this as an intermediate stage to provide all-IP to some customers.

In this strategy optical fibre was laid all the way to the curbside, though not to individual dwellings. At the curbside, Ethernet switches were deployed.

Originally devised with Ethernet over passive optics with splitters to the switches, the switches could be located up to 2.7km from the user but it was only capable of around 2Mbit/s over a single pair at these distances. A second generation introduced a 2-wire Ethernet over copper with a line speed of around 10Mbit/s over a single pair but required the switch to be within 750 metres of the user.

Currently Gigabit Ethernet over PON (GEPON) is specified in The Institute of Electrical and Electronic Engineers (IEEE) 802.3ah and 10GEPON (10Gbit/s) is in development as IEEE 802.3av. Both of these however require conventional Ethernet over copper distribution over four-pair Category 5e/6/6A with a distance limit of 100 metres. And this means that the terminal electronics need to be inside the building not at the curbside.

Effectively this means that Fibre-to-the-Curb is no longer practical, and operators should now go directly to FTTP either using PON or point-to-point as described in the following sections.

FTTP: PASSIVE OPTIC NETWORK

Some operators have already elected to move directly from their legacy copper architecture to FTTP PON. Like the old copper distribution network, FTTP (PON) returns operators to a purely passive distribution network and removes all the operational difficulties of active equipment deployment in the OSP.

FTTP requires a very high OSP investment because fibre must be dug-in not only from the CO (or PoP) to the node, but from there all the way to each customer.

There are a number of standards for PON.

ATM PON (APON) and Broadband PON (BPON) (see standards section below for definitions) have been widely deployed internationally but are now superseded for new installations by Gigabit PON (GPON) and GEPON. GPON is most common in the West, GEPON more common in Asia.

GPON is standardised by the ITU and has a physical reach of at least 20km. It supports various bit rate options using the same protocol, including symmetrical 622Mbit/s, symmetrical 1.25Gbit/s, 2.5Gbit/s downstream and 1.25Gbit/s upstream and more.

A multifunctional standard, GPON supports voice, TDM, Ethernet (10/100Mbit/s), ATM, leased lines, wireless extension and more.

Currently GEPON is standardised by the IEEE and allows full duplex Gigabit over a single fibre from the core to be routed to a fibre distribution hub which houses the passive optical splitters and from there through fibre distribution to every home and business. The total reach is up to 20km. The IEEE is also currently standardising 10GEPON which achieves 10Gbit/s over 20km.

Passive optical splitters allow considerable cost savings in fibre deployment as they can be placed far downstream splitting currently usually at 1:32 or 1:64 meaning that only one fibre is needed per group of 32/64 (options exist for 1:128 and even 1:256 but these are likely to be deployed only rarely) customers and each can burst data up to the full 1Gbit/s or 10Gbit/s line rate.

The development of 10GEPON itself includes an upgrade path from GEPON.

Legacy practicalities will most probably dictate where the splitters reside in the network. Ideally they should be fairly close to the customer as this allows the cost advantages of single-fibre backhaul to be maximised. However if an FTTN intermediate stage has been used, the location of the FTTN node will in many cases be the most logical place to install the fibre distribution hub and splitters. An alternative is to use the old node location simply for fibre distribution and take single fibres further downstream, installing fibre distribution hubs with splitters in individual neighbourhoods.

In some networks it may be decided to cascade the splitters in two or more stages, though this can lead to spare ports being 'stranded' in areas of low demand, obviously resulting in wasted capital and installation expenses.

Already we are seeing horrendous engineering mistakes in the field where the massive core routers for NGN are being installed with inadequate connectivity

PON STANDARDS

- ITU-T G.983 APON. This was the first PON standard. It was used primarily for business applications and was based on ATM.

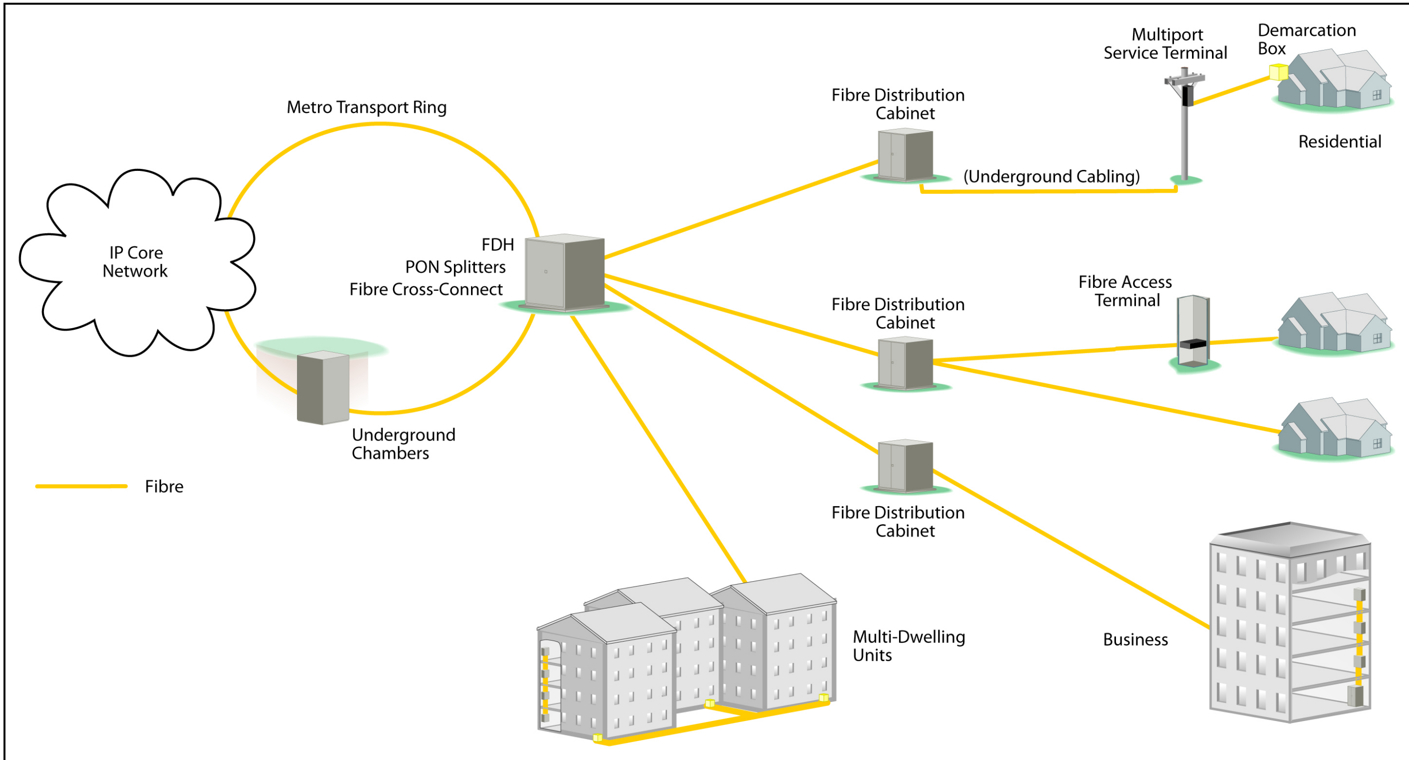

Figure 4 FTTP: Passive optic network

- ITU-T G.983 BPON is a standard based on APON. It adds support for wavelength division multiplexing, dynamic and higher upstream bandwidth allocation, and survivability. It also created a standard management interface, called OMCI (Open Manage Client Instrumentation), between the optical line terminal (OLT) and the user's optical network unit/terminal (ONU/ONT), enabling mixed-vendor networks.
- ITU-T G.984 GPON is an evolution of the BPON standard. It supports higher rates, enhanced security, and choice of Layer 2 protocol (ATM, GEM (GPON Encapsulation Method), Ethernet).
- IEEE 802.3ah EPON or GEPON is an IEEE/EFM (Ethernet in the first mile) standard for using Ethernet for packet data.
- IEEE 802.3av 10GEPON is an IEEE Task Force for 10Gbit/s backwards compatible with 802.3ah EPON. 10GEPON will likely be multi-lambda downstream and continue to use a single lambda with ATDMA (Advanced Time Division Multiple Access) for upstream. It will also be wavelength division multiplex-PON compatible.

ADVANTAGES

- Maximum bandwidth delivery – a group of users share 1Gbit/s or 10Gbit/s with burst speeds up to the full line rate;
- All-passive access network, no electronics in harsh OSP environments;
- Can be all-IP from the core network, using GOPN, GEPON or 10GEPON.

DISADVANTAGES

- High investment required to dig fibre to every home and business, although this needs to be weighed against the capital and operational costs and operational challenges of active electronics in the OSP.

CHALLENGES

- Migration from FTTN deployments;
- Fibre management and hardened crossconnects on the OSP;
- Fibre drops to individual homes and businesses.

FTTP: POINT-TO-POINT

Point–to-point fibre is highly analogous to copper in the access network.

The fibre is run through a similar tree-and-branch access network topology from a CO or PoP, through several fibre flexibility points or cross-connection nodes, finally to each home and business.

Two aspects are different to copper, however. The first is the massive available modal bandwidth. Using single-mode fibre, a single fibre or fibre pair can deliver many Gbit/s split between transmit and receive paths. The second difference is the maximum distance from CO or PoP to the user. Whereas copper was limited to about 5km, single mode fibre can achieve these phenomenal data rates up to 50km. In a greenfield environment this can permit a core network with far fewer PoPs than there were previously COs. However the practicalities of reusing existing duct routes and buildings may mean that in reality this benefit cannot be fully exploited.

Finally, compared to the various 'flavours' of PON (where there is OSP equipment such as the splitters which may need to be upgraded in the field to provide faster data rates to the customer) with point-to-point, only the network-end OLT and customer-end ONU/ONT equipment needs to be upgraded.

Point-to-point topology means that a great many more Optical Distribution Frame (ODF) ports are needed on the CO or PoP – because there are one or two fibres per customer (plus of course spares for future growth.) Between the fibre hub/crossconnect and the customer, there is in essence no difference between the PON and point-to-point access network.

From an economic perspective, point-to-point is more expensive than PON over longer distances because far more kilometres of fibre have to be deployed between the fibre hub/cross connect and the CO or PoP. This is in comparison to the PON situation where only one fibre (or fibre pair) is needed per 32 or 64 customers (128 or even 256 customers on rare occasions).

From a bandwidth perspective, since this is not being shared between customers, then the ultimate bandwidth delivery potential is far higher.

As a result of this greater cost, many networks will see a mix of point-to-point for metropolitan and urban networks and PON for rural.

ADVANTAGES

- No OSP upgrades are needed to increase customer bandwidth;
- No active electronics in the OSP.

DISADVANTAGES

- Possibly the most costly option in terms of capital outlay;
- Fibre or fibre pair to be terminated and managed for each customer premises.

CHALLENGES

- Digging-in fibre to every customer premises;
- Providing fibre flexibility points in the OSP and undertaking media access controls;
- Whether to splice or use hardened connectors for flexibility points in OSP;
- Providing and maintaining ONUs in the customers' premises;
- Fibre distribution in multiple occupation buildings and multiple dwelling units;
- High volumes of OLT equipment in the CO/PoP;
- High volumes of ODF ports required;
- Underground splices and joints in the OSP;
- Fibre drop-cables;
- In building and multi-tenant distribution.

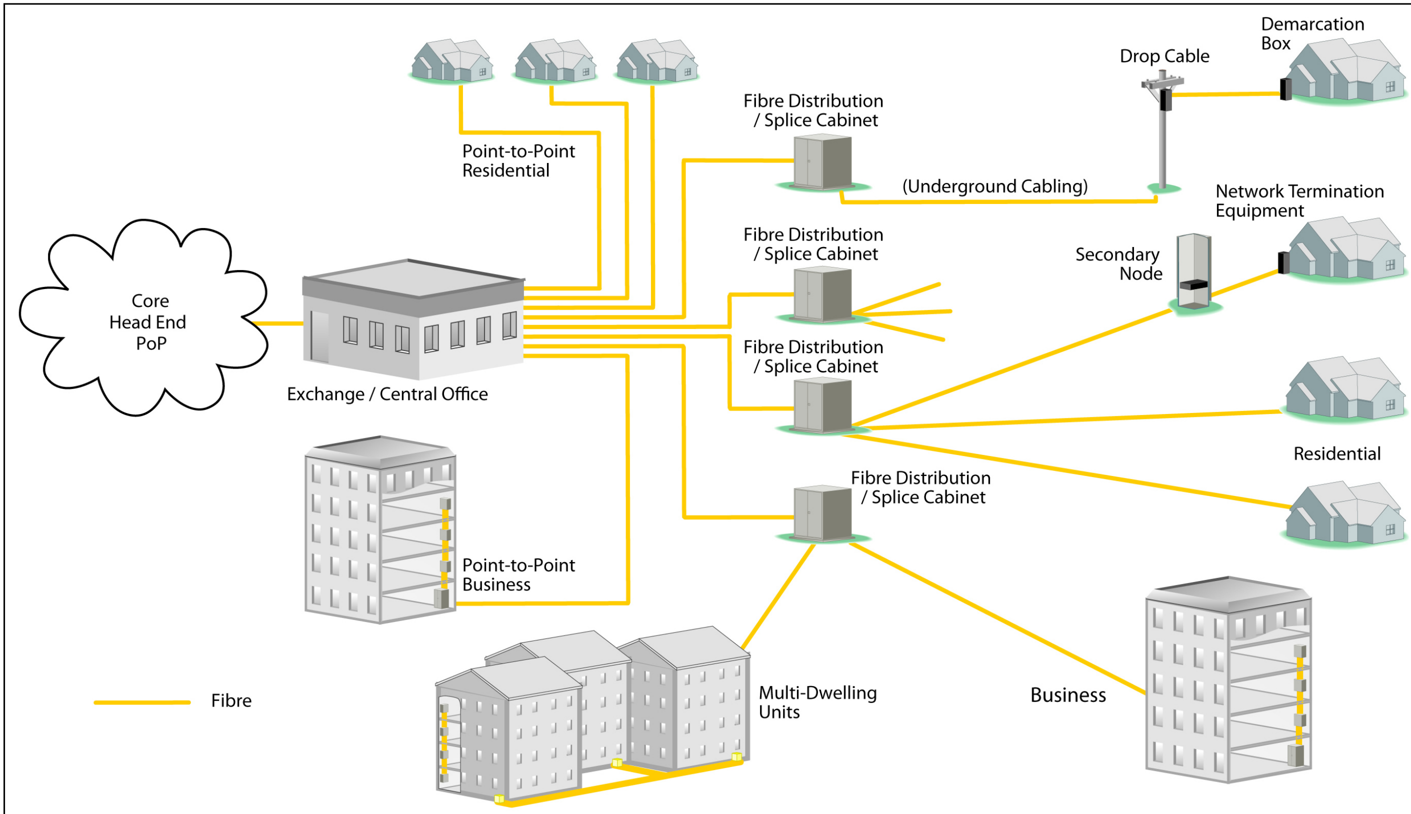

Figure 5 FTTP: Point-to-Point

MIGRATION TO IP IN THE CORE NETWORK

For many operators, the logical first step to all-IP is actually to update the trunk or core network.

This means a wholesale change away from TDM digital main switching centres with Signalling System No 7 and from transmission using SDH, SONET and maybe even legacy plesiochronous digital hierarchy links. Some of this will already be transmitted over fibre; some may still be on coaxial systems.

Instead, the all-IP core network will be based around massive routers and Ethernet core switches providing the bit transport infrastructure while IP-based centralised systems like IMS (IP multi-media sub-system), SIP (Session Initiation Protocol) for voice over IP call control are linked into the core at various points to provide the 'services' that the all-IP bit transport network will then carry to users.

What 'shape' or topology this new core network will take depends on a number of factors including the IP-roll-out strategy chosen for the access network.

In an idealised 'green field' situation, (aided by the far greater physical reach of fibre compared to copper), a network can, theoretically be built with maybe one tenth of the number of PoPs compared to the number of COs in a legacy copper-based network. Reducing the number of buildings in the network could represent a massive saving in land and buildings alone, not to mention the equipment and manpower savings.

One operator plans to replace some 6,000 CO locations with only 100 PoPs and 20 mega PoPs and of course many thousand MSANs in the OSP.

For many networks this could still be the ultimate end-goal but practicality of roll-out will often mean that existing CO buildings, duct routes and OSP cross-connect locations must be retained in order to minimise the costs of highly expensive digs and civil works in the access network.

Whichever strategy is chosen, it is clear that change must be allowed for. Investment in proper fibre flexibility and management, with total attention to detail, will be repaid many times over in terms of ease of equipment upgrades, extensions, relocation, site closures and consolidations etc.

Unfortunately, our engineers are finding numerous situations in operators' networks where massive new core routers have been installed without the necessary flexibility around them – leading to operational difficulties within months of deployment. These problems can be rectified for the operators, but it would have been far cheaper and less disruptive if this aspect had been properly considered at the router planning and deployment stages.

We know that connectivity is far from exciting and tends to be very low down on most executives' lists because it is 'minute detail'. However, it is the attention to this detail which can avoid serious operational difficulties and ultimately makes a massive difference to cost effective service delivery.

The good news is that whether you are a network operator or equipment manufacturer, there's no need to try to learn this detail yourself. There are excellent companies in the networking industry with great experience of this kind of work which means that specialist skills and expertise are available to help with these essential aspects of the detailed network design.

ADVANTAGES

- Can possibly dispose of hundreds or thousands of CO buildings.

DISADVANTAGES

- Massive amounts of fibre to be managed and cross-connected in the PoP/Mega PoP.

CHALLENGES

- Providing some legacy services is problematic such as: copper alarm lines, local 2-wire and 4-wire 'private circuits', external extensions, 2Mbit/s leased lines and others.

IN CONCLUSION

The one thing that is totally certain in all of these strategic options (many of which will necessarily have to be deployed and rolled out in the same network at the same time but at different roll-out rates) is that the network will be constantly changing. In fact it may be that the rate of change actually continues to accelerate. Even when so called 'ultimate' strategies like fibre to the home/premises have been rolled out, customers' voracious appetite for ever higher bandwidth will mean that network upgrades continue to be needed and customers will continue to move dwellings and business premises as they always have meaning that will be the daily round of moves, adds and changes.

Bear in mind too that while telecommunications network active equipment previously had an operational life of up to 20 years, this is now going to be only seven or even less – meaning that even more changes than ever will be taking place in the net work equipment domain.

Already we are seeing horrendous engineering mistakes in the field where the massive core routers for NGN are being installed with inadequate connectivity (cross-connection or flexibility frames) around them – with the unbelievable but true outcome that often there is no test access and, when units fail, it is impossible to transfer the live traffic onto other working equipment.

We have even come across sites with duplicated routers where the lack of connectivity means that the only way to upgrade or extend one of the routers is to take the whole PoP out of service – because there just isn't the connectivity to patch the traffic within the PoP. Unbelievable perhaps, but it seems the 'flexibility' ethos of the old-hand telecommunications engineer has been lost – and, if both network operators and equipment manufacturers don't re-learn this skill very quickly, then the expected cost-benefits of IP networks simply won't be realised.

ABBREVIATIONS

ADSL	Asymmetric Digital Subscriber Loop
ATM	Asynchronous Transfer Mode
APON	ATM Passive Optical Network
BPON	Broadband Passive Optical Network
CO	Central Office
DSL	Digital Subscriber Loop
DSLAM	Digital Subscriber Loop Access Multiplexer
EPON	Ethernet PON
FTTB	Fibre to the Building
FTTN	Fibre to the Node
FTTP	Fibre to the Premise
GEPON	Gigabit Ethernet over PON
GPON	Gigabit PON
HD	High Definition
HDTV	High Definition Television
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISDN	Integrated Services Digital Network
IT	Information Technology
ITU	International Telecommunications Union
MPEG	Motion Pictures (Coding) Experts Group
MSAN	Multi-Service Access Node
NGN	Next Generation Network
ODF	Optical Distribution Frame
OLT	Optical Line Terminal
ONU	Optical Network Unit
OSP	Outside Plant
PON	Passive Optical Network
PoP	Point of Presence
POTS	Plain Old Telephone Service
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
TDM	Time-Division Multiplexing
VDSL	Very high speed Digital Subscriber Loop

ACKNOWLEDGEMENTS

This article was first published in *The Journal of the Institute of Telecommunications Professionals*. 3 (1), 2009: pp. 41–48. ISSN 1447-4739.

Cite this article as: Storbeck, Carsten. 2010. 'Migrating to the uncertain'. *Telecommunications Journal of Australia*. 60 (3): pp. 33.1 to 33.18. DOI: 10.2104/tja10033.