Migrating from Copper to Fibre: THE TELCO PERSPECTIVE

A WHITE PAPER BY THE DEPLOYMENT & OPERATIONS COMMITTEE

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Fibre to the Home Council Europe

CONNECTING **EVERYONE** AND **EVERYTHING**, **EVERYWHERE**

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1. Introduction

Meeting consumer expectations is an ever-increasing challenge for access network providers. The killer application pushing the demand for peak speeds is no longer video, but merely human impatience when downloading or uploading large files. The personal cloud is one example where users need to quickly transfer and synchronise huge files and databases with a central data centre. As a result, network operators are looking to upgrade their current networks in the most cost-effective manner, to avoid losing existing customers and to attract new ones in a highly competitive market.

The most powerful and future-proof solution to address all broadband access requirements is fibre to the home (FTTH), which provides communication over an end-to-end, direct fibre connection into every household, whether a single family home or a living unit in a multi-dwelling unit (MDU). While deploying a new-build FTTH network is not a simple task by itself, an incumbent operator also faces the challenge of managing the upgrade of its legacy infrastructure to future-proof fibre. As the assets of an incumbent telco reside primarily underground, many operators have chosen to leave them in place and opt for short-term investments that make their networks last just a bit longer.

However, with the advent of the “gigabit era”, incremental upgrades are no longer a viable strategy, and many operators are forced to reconsider the future of their copper infrastructure. Building a deep-fibre architecture in the access network presents them with several challenges.

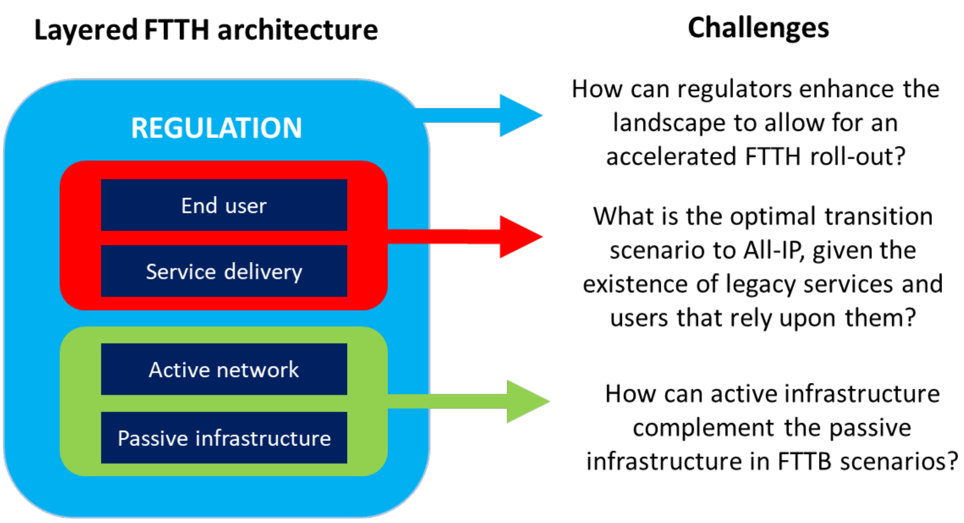

Figure 1: Challenges faced by incumbent operators looking to upgrade copper networks to fibre

For single family homes, the technology choices are relatively straightforward as the connection is usually "fiberized" all the way to the customer. For MDUs, the situation is more complicated. Deploying FTTH inside MDUs requires optical fibres to be installed from the basement, where the external fibres enter the building, to every floor and apartment. Even with advances in installation techniques, the process can present practical difficulties, especially in Europe where many MDUs were built even before the arrival of telephony. Nevertheless, MDUs represent a huge addressable market, and operators would like to address this market in a more cost-effective way. We will discuss new technologies that make this possible.

As well as their copper assets, incumbent operators are further burdened by their legacy services portfolio. It requires significant effort to migrate these legacy services to IP-based replacements, if they even exist. A modern All-IP core network is a prerequisite for an operator to transform its legacy network into a state-of-the-art FTTH network, but even a stand-alone IP transformation has a positive underlying business case. We will discuss an operator's options when migrating to an All-IP network.

A final hurdle to overcome is regulation, which may negatively impact the operator's business case to the extent where deploying fibre is no longer a viable option. In this paper, we provide some recommendations for regulators to improve the penetration of broadband access in their country. We conclude with suggestions for regulators to accelerate the pace of gigabit broadband roll-out in their respective countries.

2. Enabling Broadband Technologies

2.1 The challenge of passive infrastructure in FTTB

There are several FTTB configurations for a telco operator wishing to install optical network terminal (ONT) to distribute IP traffic in the MDU. The preferred option is of course to bring fibre to each individual living unit within the MDU (true FTTH). However, for existing buildings, operators must deal with the logistical challenges associated with getting permission to access each individual living unit within the building to install equipment and fibre. This was the subject of a previous white paper from the FTTH Council Europe, entitled 'Optimising Fibre Installation Inside the Multiple Dwelling Unit'.

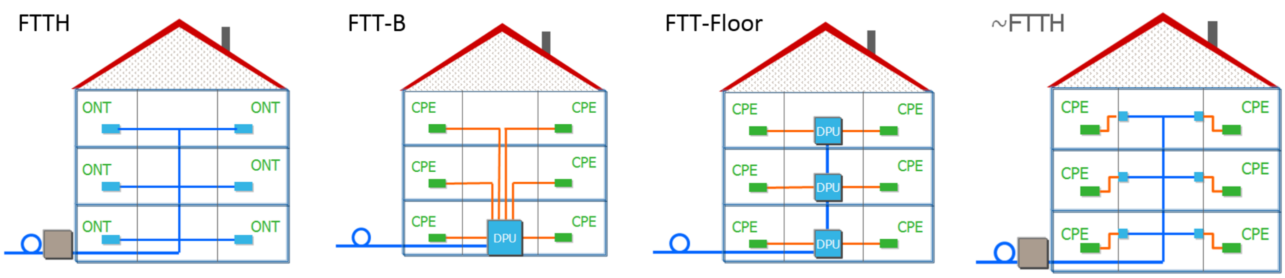

Figure 2: FTTB variants differ in where the fibre terminates.

Instead of bringing fibre into each living unit, the ONT can also be placed in a central location on each floor of the building. When multiple homes are connected to an ONT, it is referred to as a distribution point unit (DPU), as it is part of the managed infrastructure of the operator. Though this method pushes the fibre termination further into the building, eliminating parts of the copper network, multiple units are still sharing the bandwidth over a single fibre connection. In practice, this may not have an impact on the service rate experienced by end users, because users also share bandwidth in a PON deployment.

This approach solves the operational challenges associated with the need to have appointments with individual end users, and places the burden and responsibility for providing space, power and maintenance of the ONT on the building owner. However, an operational challenge that is not addressed in such DPU deployments is the distribution of the fibre through the vertical ducts, which are often the most difficult to deal with, although new installation methods have made this easier in recent years.

An alternative is to place the ONTs in a single centralised location. This deployment may impact service levels, because of increased crosstalk and poor quality twisted-pair copper cables in the service ducts and risers. However, recent advances in copper technology have been specifically designed to deal with these impairments, and it is now possible to deliver gigabit services in this scenario. This deployment places the responsibility for cost and power with the operator or building owner, depending on the sales agreement.

There are three types of copper-based media, along with appropriate transmission standards, that can be used for in-house cabling in combination with the various FTTB models described:

1. **Telephone-grade twisted-pair copper** is available in virtually every home in Europe. Often more than one copper pair is available per household, which allows bonding technologies to be employed. Technologies used over this medium belong to the Digital Subscriber Line (DSL) family. Today, VDSL2 technology is commonplace, and a new DSL variant, G.fast, is already being deployed in the field while ITU is working on G.fast’s successor, G.mgfast, which aims to get 10Gb/s into the home.

2. **Coaxial TV infrastructure** is available in many buildings across Europe, fed with signals from cable companies or from local CATV systems. Typically, new buildings are equipped with point to point (P2P) cables. However, point to multi-point coax may also be deployed in a substantial portion of an operator’s network. A variety of transmission technologies can be employed over this media, including DOCSIS 3.x or Ethernet over Coax (EoC), while for P2P networks, G.fast is also an option.

3. **New Cat5/6-e cabling,** which usually is not available as legacy infrastructure but must be installed by the service provider. This medium supports Gigabit Ethernet.

For a telco operator, twisted-pair copper cable is the most straightforward answer; but coaxial cable may also be an option, as it may be owned by the building owner rather than the cable operator that deployed it. Coax has better characteristics with respect to signal degradation, so would be the preferred choice. However, this option may be limited by significant regulatory constraints, on unbundling, for example.

2.2 Active network infrastructure to the rescue

Active technologies have been developed that allow operators to enter the gigabit era cost-effectively, even in an FTTB scenario. Where telco operators are lucky enough to find CAT5 (or higher) cable already deployed, Ethernet LAN technology allows them to deliver gigabit services to each living unit.

However, the majority of MDUs are only wired with copper pairs. To efficiently deploy fibre service in these buildings, VDSL2 has been widely adopted for in-building service delivery. In fact, in the early days, more than half of deployments marketed as FTTH were actually FTTB with VDSL2. With vectoring, VDSL2 can deliver aggregate bit rates in excess of 150Mbps (100+ Mbps downstream). The latest VDSL2 profile to be standardised is a 35MHz profile, which doubles the speeds of VDSL2 17a up to 300Mb/s, while being compatible, in terms of vectoring, with the installed base of VDSL2 17a modems. VDSL2 vectoring can be combined with G.998.4 (also known as G.INP), which adds stability and additional resistance to impulse noise. As a result, VDSL2 vectoring remains a solid option for addressing the challenges associated with these types of installations.

The latest technology, G.fast, offers the best of both worlds. It can run on legacy copper infrastructure (both twisted copper pairs, as well as P2P coax) while supporting fibre-like bitrates, of up to 2Gb/s aggregate in its 212MHz profile, over very short loops. Since it was designed for use in the outside plant, it also includes measures to protect against noise and other issues that could impair performance, all features that Ethernet may lack in typical installations.

Another technical option to reduce costs in an FTTB deployment is reverse powering. This approach eliminates the cost of installing a power meter, which is often required to monitor active equipment in the basement of an MDU. The cost of such a power meter can be unexpectedly high, and may even break the business case for the FTTB deployment. Thus, reverse powering was invented. In reverse powering, the active equipment is powered from the customer equipment over the copper pair that is carrying the broadband signal.

3. Challenges of Voice Service Delivery

A significant number of communications service providers built a public switched telephony network (PSTN) decades ago to deliver voice services. Today, however, this legacy network has become increasingly costly to operate, and is in need of transformation. By planning and implementing PSTN transformation at the same time as their ultra-fast broadband deployments, operators can ensure greater success and cost-efficiencies.

3.1 Why PSTN needs transformation

First, the PSTN relies on aging products and technology that has high maintenance costs, high energy consumption, requires large amounts of central office space, and lacks skilled experts to maintain it. On the other hand, revenues from PSTN services are decreasing as an increasing number of users (especially “millennials”) cancel their land lines and opt for mobile voice or newer services over broadband instead.

In spite of this, in 2017 about 70% of the world's 650 million fixed lines are still using the PSTN, so it makes sense to optimise the PSTN, in order to decrease the cost to serve voice customers and increase revenues by enabling more competitive service offerings.

PSTN transformation is a major project that requires a well-planned strategy to deal with the complexity of the transformation while at the same time considering users' needs. Are there legal obligations to provide lifeline services? Are customers willing to change services? Will service migration open the door to competitors? Are there enterprise customers that still require leased lines?

Furthermore, legacy networks are rarely homogeneous; they are typically a patchwork of separate networks, which increases complexity still further. The diversity in networks (and the equipment running them) can be the result of market forces, via mergers and acquisitions, or driven by service requirements, such as different enterprise and consumer technologies. These separate networks may require different planning, approaches, and management, that will need to be unified at least strategically for the transformation to become a success.

It is possible to successfully manage all these migrations, however; and ultra-fast broadband deployment represents the perfect opportunity for operators to transform the PSTN. OPEX savings predominantly drive the business case for PSTN migration. The key financial metrics of the business case improve when the broadband deployment and PSTN migration projects are conducted concurrently. This is primarily due to the shared cost of the street cabinets, which terminate the copper loops for both the PSTN analogue and xDSL lines. Additionally, the cost of labour is shared between both projects. Therefore, overall access and PSTN migration plans must be aligned to derive the full financial and technical benefits.

3.2 Voice over broadband and voice over narrowband

To emulate PSTN services, two options can be considered: Voice over broadband (VoBB) or voice over narrowband (VoNB). The key difference between the two is the location of the voice gateway functionality – in other words, the session initiation protocol (SIP) endpoint and analogue-to-digital conversion point.

With VoBB, the voice gateway functionality is at the end user site, for example, at the integrated access device (IAD), the DSL modem or the ONT. Conversion is performed very early in the network. With voice over narrowband, the voice gateway is located in the DPU. Conversion happens in the network, at the cabinet or central office (CO).

Both VoBB and VoNB can provide a near-perfect emulation of PSTN services, supporting all legacy requirements. Migration is transparent to end users, who can continue to use their existing analogue phones. Voice over broadband can also be used to simulate most popular PSTN services. The simulated services may behave differently in specific instances, but they provide service providers with opportunities to introduce customers with IP phones to new services like push-to-call and IP Centrex (hosted PBX).

Both technologies allow operators to update their core network to IP. However, voice over narrowband does offer some particularly compelling advantages to service providers. These advantages include:

- **Zero end-user impact**: Voice over narrowband offers totally transparent migration. Service providers can maintain service continuity without truck rolls, phone calls or additional appointments with the end user.
- **No additional costs for the customer**: With voice over narrowband, the equipment is in the network. There's no need to install new equipment at end user premises.
- **A gateway to broadband**: In areas where broadband deployments are not advanced, migration to voice over narrowband puts service providers in better position for future broadband rollouts.
- **Lower operating costs**: Voice over narrowband offers easy maintenance. All POTS interfaces are in the network, and there are no IP phones that could require end user support. In addition, the technology will have a small footprint and reduce power consumption in the CO.

3.3 A three-step approach to PSTN migration success

First, an operator needs to plan effectively, to assess their internal capabilities, anticipate and mitigate risks, and define a realistic view of the migration and post-migration operations. The delivery model should identify capability gaps, which are present in most operators. Many lack a complete understanding of PSTN services, given the diminishing pool of skilled employees, and the focus on newer technologies.

In a second phase, it is important that the identified gaps are closed, as key capabilities need to be in place for a successful transformation. With a large-scale project like PSTN migration, these gaps cannot be covered by simply adding more employees or contractors or applying routine migration techniques. It demands specialised skills, techniques, and tools.

Finally, an operator needs to adopt a vertical approach: many activities must be executed in parallel, allowing work to be carried out on multiple switches in different locations at the same time. The key elements of such a vertical approach are:

- A dedicated migration team with expertise in technology, logistics, and project management can ensure vertically aligned execution.
- Specialised workforce management tools can streamline resource and task management, helping to keep the migration project on target and on budget.
- Tools designed for mass data migration can help service providers handle diverse or disparate data faster and more accurately.
- Purpose-built verification, testing, and cutover tools can help field technicians work with more speed and quality.

3.4 Dealing with the long tail of PSTN migration

When transforming a legacy PSTN to All-IP, it is the final 2% of specific use cases – the long tail – that represent the biggest challenge. These use cases include:

- old devices and CPE that can't be supported on an IP network;

- legacy signalling, such as ISDN-basic rate, and specific services, such as operator-assisted dialling, that do not have equivalent feature parity in an IP network; and
- regulatory compliance for things such as universal coverage and emergency services.

While there is no one-size-fits-all solution, industry best practices show that the most common adopted approaches are (a mix of) commercial (VoBB) and technical (VoNB) migrations, consolidation or elimination of the service. Business customers and regulatory compliance present specific challenges. Therefore, negotiation and cooperation with stakeholders is advised, and sometimes required, to find the best-fit solution to phase out long-tail PSTN services.

4. Competition and Regulation

The benefits of migrating towards an All-IP broadband network have been discussed, as have detailed strategies and technologies that can help incumbent operators to ease through this transition. However, there are still opportunities for regulators to increase the speed of transition by providing confidence to market actors and investors, and by lowering the perceived risks to enter or to mature in the fibre market.

4.1 A stable regulatory environment

In the so-called “less dense” areas, which are less profitable for operators and where the need for public intervention is generally greater, European regulators should aim to create and maintain a fair, dynamic, competitive and secure environment for all operators – even the incumbents, because the speed of migration towards fibre is the most important factor for profitability, more so than the cost per line. Fibre networks could become one of the most profitable public investments, while providing numerous externalities, and expanding the playing field for both existing and new European operators.

In such a “confident” framework, operators would be suitably equipped with the techniques and processes to deal with the migration of their legacy services based on copper loops to new services over fibre access in a short time frame. To attain these positive outcomes, European regulators should define a strategy that enables the entire ecosystem to enter a “virtuous circle”, by following some key principles:

- Create and maintain a dynamic and predictable environment for fibre players;
- Reduce unfair and non-neutral competition from legacy services based on copper, while also guaranteeing the business of former investors as the incumbents; and
- Promote all the positive outcomes from ubiquitous European fibre networks.

The initial services to migrate to fibre will be existing services that are not sufficiently or efficiently supported for the whole population on copper, even with upgraded technologies like VDSL2 and G.fast. Next will be new services and applications that require fibre, either directly or indirectly. However, many factors could hold back this migration. More specifically this migration could be slowed down, not for technical reasons or low demand, but by unfair competition or a static environment.

For example, a static environment could result from the historical dominance of copper operators, not just from the incumbents but also from operators who have built their businesses on unbundled copper products. Also, unfair competition could arise from the copper network itself, which historically benefits from uniform pricing everywhere.

Indeed, because of a countrywide flat tariff, copper unbundling prices could be comparatively lower in less dense areas compared to its local cost. This would create unfair competition for fibre networks in these areas, lowering the speed of migration and thus reducing profitability, which puts the subsequent economic and sociologic benefits at risk in those areas.

As an illustration, in less dense areas, even though it may cost less to build a new fibre network than to upgrade the existing copper network, the copper unbundling price may remain around 9€–10€ per month, a tariff that the local fibre operator will find it difficult to compete with unless he is sure of rapid customer migration – confidence that only comes when the appropriate regulatory measures and incentives are in place.

4.2 Scenarios to safeguard the interests of copper investors

To overcome this problem and to ensure faster migration towards fibre, various scenarios have been studied, based around actions that could be taken to safeguard the interests of former copper investors, while also providing incentives and confidence to those wishing to invest in fibre [See References, p11]. These scenarios are not exhaustive; other approaches could be developed to reach a similar outcome. The scenarios could be used alone or in concert, and are relatively simple to implement in Europe.

These scenarios modify the differential between copper unbundling tariffs and wholesale fibre access rates, in order to create a virtuous circle where there are greater financial and competitive incentives for market players to migrate towards fibre, rather than staying on copper. In addition, these scenarios have been structured to preserve the business of the stakeholders in the copper access network.

- **Scenario A**. Announce that regulated uniform copper access unbundling rates will evolve upward. This is due to the decrease in the number of copper access lines in conjunction with the remainder of historical fixed costs and the increasing maintenance costs for the whole network.

- **Scenario A***bis*. Let the copper unbundling rates evolve with a minimal announced upward trend.

- **Scenario B**. Apply a contribution* on fixed data access lines according to a bit-rate criterion and reverse this contribution to subsidise fibre in less competitive and attractive areas.

- **Scenario B***bis*. Apply a contribution* on all data fixed access lines, even fibre lines, and then use this contribution to subsidise fibre lines in less competitive and attractive areas.

- **Scenario C**. Correct locally the unfair competition from flat rate pricing of copper loops.

- **Scenario D**. Temporary buy back of the copper network, where the state takes over the copper network, and sells it back after the upgrade at specified terms and conditions.

(*A contribution is a tax or dues applied on the telecommunication domain with benefits are wholly used in the same telecommunication domain boundary. This is a bonus-malus mechanism.)

These scenarios, from the easier scenario A to the more challenging ones like scenario D, are examples of possible strategies that could be used by local regulatory authorities and EU-level institutions to speed up the migration from copper towards fibre while maintaining and improving competition and thus investment.

5. Conclusions

In this paper, we have highlighted some of the challenges for telcos looking to migrate from copper towards FTTH infrastructure. Indeed, these challenges are far greater than simply making the necessary investment in a new fibre distribution network. We have discussed copper technologies that been developed to assist the in-home distribution of broadband services over legacy media, which are mainly applicable to the deployment of FTTB in (large) MDUs. This further allows a flexible placement of the ONT. Further, we have discussed the challenge of migrating legacy service portfolios to an All-IP environment, with PSTN migration as an example. This PSTN service migration has its own positive business case, and hence does not depend on a strategic decision to move to a fibre network. Finally, we have presented different scenarios describing mechanisms that regulators may use to accelerate the pace of FTTH roll-out in their respective countries.

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