



Creating a brighter future

FTTH Business Guide

Edition 5

Financing Committee

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Foreword

The FTTH Business Guide has become a major best-seller. The 4th edition, produced in 2012, had a following of more than 15,000 readers – either online or in the printed version. The obvious success of this Guide was a big motivating factor in bringing together all Working Committees of the FTTH Council Europe under the lead of the Finance Committee to produce a new updated version.

The Business Guide 5.0 is not a simple update of the 4th edition but reflects the changes, opportunities and new challenges of the European FTTH market. With the European FTTH market becoming more mature and financing has never been cheaper than it is today, FTTH is being recognized as an asset in the financier's portfolios and the passive part of the network as being a valuable infrastructure investment.

Developments on the European level such as the EFSI (Junker's plan) or on a regional level demonstrate the willingness and importance that real broadband access networks "FTTH" represent for them. Still a chasm exists between project owners and financiers that we believe, with the help of this 5.0 Business Guide we can go some way to bridging.

In such a dynamic environment it is important to have access to neutral and reliable information. The FTTH Council Europe sees the Business Guide as fulfilling this requirement offering the reader all necessary know-how in how to establish a fibre access business. The Guide includes a description of the full process of the development of an FTTH deployment; by beginning with the business case followed by how to plan the networks, to deployment and finally to operation.

We will continue to further develop the Business Guide with the help of your ideas and your feedback. So, please don't hesitate to contact the FTTH Council Europe if you need more information or would like to see additional chapters included.



Joeri Van Bogaert, Chair of the Business Committee

FTTH Council Europe

A handwritten signature in blue ink, which appears to read 'Van Bogaert', with a stylized flourish at the end.

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First and Second editions were edited by **Pauline Rigby**, freelance editor.

Third, fourth and fifth editions were revised and edited by **Eileen Connolly Bull**, Connolly Communication.

Who should read this guide?

The Business Guide discusses the business case for fibre-to-the-home and the major influences on the business plan and should be read by those thinking of planning, constructing or investing in a fibre access network, or have already started this process and want to find out more.

This guide is for:

- municipalities or local governments
- utility companies
- telecoms operators
- real-estate developers
- residential associations
- community project teams
- bankers
- venture capital investors
- anyone interested in the business case for FTTH
- EU, national and regional staff of public administration, regulators

This Guide targets a wide audience and therefore does not assume any prior knowledge of technical or commercial issues relating to FTTH networks. For more information on FTTH technology and deployment we recommend the FTTH Handbook, available via the links given below:

<http://www.ftthcouncil.eu>

Chapter 1: FTTH/B Market Update

European Broadband Targets

Digital Agenda targets: In March 2010 the European Commission launched the “Europe 2020” strategy to prepare the EU economy for the next decade.

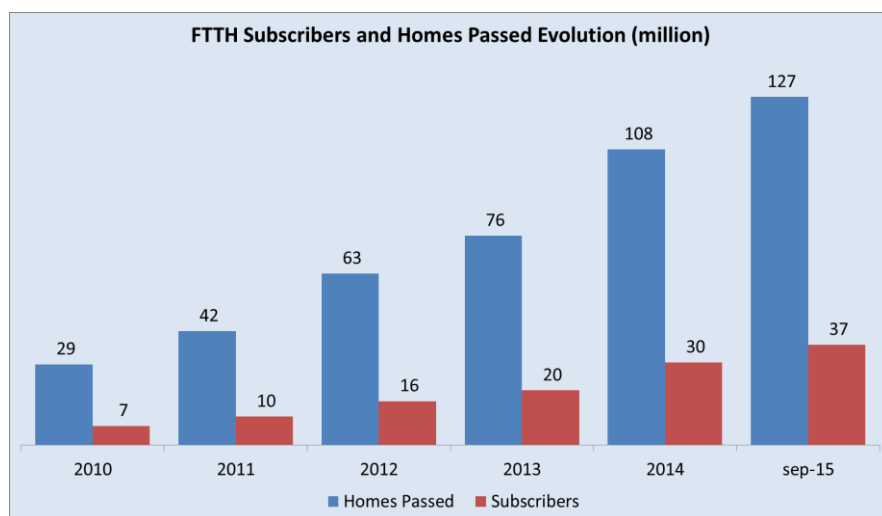
The Commission has identified the need to increase European access to high-speed internet connections. The Digital Agenda restates the objective endorsed by the European Council to bring basic broadband to all Europeans by 2013 and adds a more ambitious target for 2020: **30 Mbps available to all households with a 50% subscription rate to offers of 100 Mbps minimum.**

The Commission is reviewing these broadband targets and new targets are expected to emerge in the course of 2016. While the targets are aspirational, they provide an objective for public authorities that are building networks and importantly, set a network performance goal for NRAs to strive for.

See Appendix A for a detailed overview of Broadband targets in Europe.

FTTH subscriber growth continues to accelerate in 2015

The growth in the number of fibre-to-the-home (FTTH) or fibre to the building (FTTB) subscribers is picking up in Europe, according to the latest figures of September 2015.



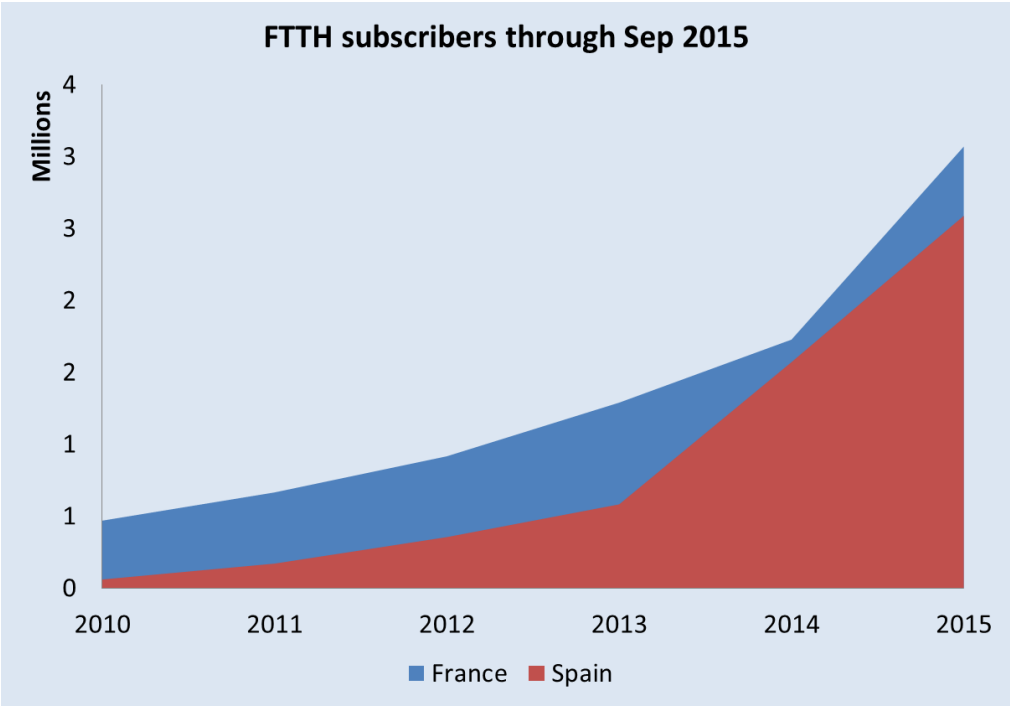
The total number of FTTH/B subscribers in Europe, in EU39 including countries also outside the European Union such as Russia and Belarus, increased by 21% in 2015 to 36.6 million. Russia alone counts almost 15 million subscribers, of which 1.6 million were added in 2015.

Up until mid-September 2015, about 127 million European (EU39) homes were passed, which continued to grow by a rate of 17% throughout the year.

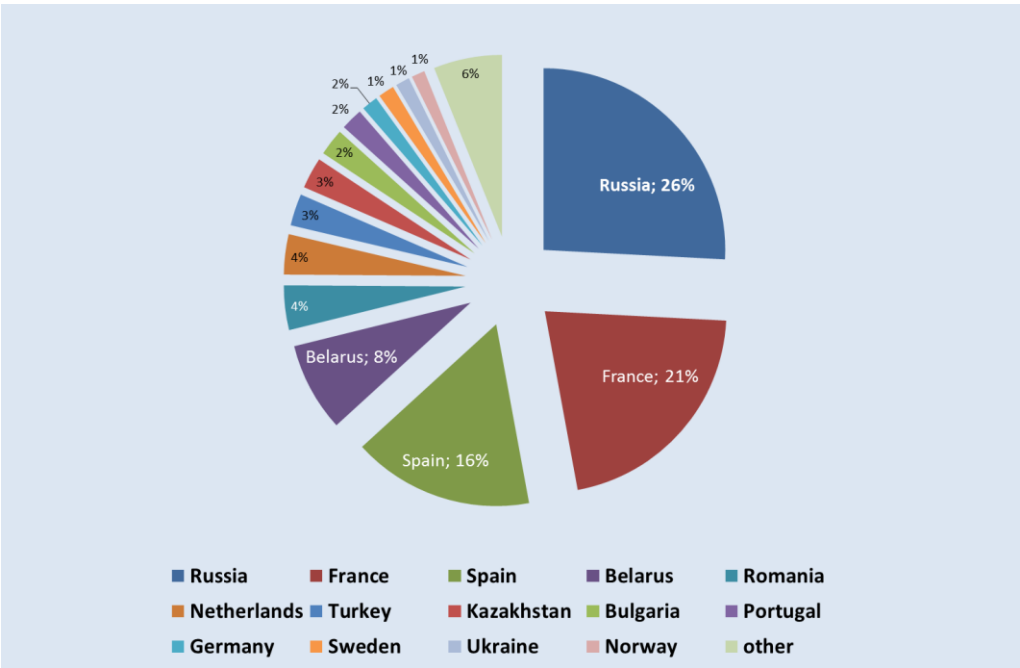
The growth rate in subscribers of 21% was greater than the increase of Homes Passed with 17%.

In total, 6 countries in the European Union experienced growth in FTTH/B subscribers of greater than 50% over the past year, including France with 78%, Spain with 65%, UK with 60%, Croatia and Poland with 50% each.

According to latest data, the largest FTTH/B markets in the European Union are France and Spain which both exceed 3 million FTTH/B subscribers in France and 2.5 million in Spain.



However, Russia, France, Spain and Belarus represent more than 70 % of new Subscribers in 2015.

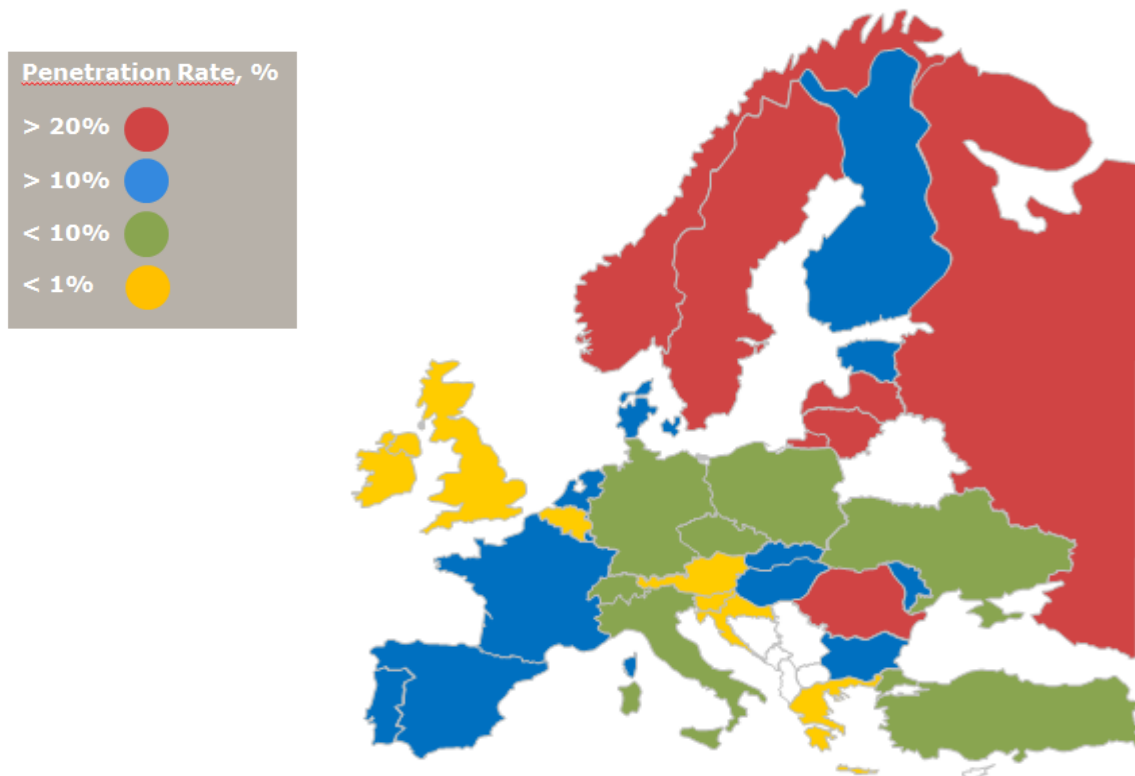


European FTTH/B Penetration – September 2015

According to the new figures, European countries are starting to move up the ranks of countries with at least 1% broadband penetration¹, as the chart shows.

6 countries even have a penetration rate higher than 20 %: Lithuania, Latvia, Sweden Russia, Norway, Romania and Bulgaria.

However, a major economy, such as the UK does not even reach 1 per cent household penetration.



Source: Idate for FTTH Council Europe

¹ **Penetration Rate** equals Subscribers divided by the number of number of households.

Chapter 2: Why Fibre?

„Smart Cities? It's the network, stupid! “

The concept of Smart Cities – or in a broader sense Smart Regions – relies on the availability of analysed information that triggers certain actions. For example, this includes but is not limited to traffic or energy management or the provision of public services in health and education. This idea is usually associated with industry buzz words such as Industry 4.0, Big Data and the Internet of Things (IoT), ie. the idea that everything is connected and everything creates data that can be utilised in some way.

However, what seems to be frequently ignored is the fact that collecting data alone does not make a city or region smart. It is the application of algorithms that turns collected data into valuable information and requires significant computing power and storage capacity. As a consequence, data must be transported to the available computing power and storage capabilities, which could be universities, offices or data centres, for instance, or more generally, the „Cloud“. Thus, *being smart* necessitates data networks which have the following features:

- high reliability, availability and stability
- low latency
- capable of providing scalable, symmetric Gbps-bandwidth

The network becomes the proverbial nervous system of a community. It would not be acceptable if a nervous system transmitted information about body functions with an incorporated time delay. Thus, the network must have the highest degree of fibre densification. There is no alternative.

In this context, one can argue that FTTH (aka Fibre-to-the-Home) deserves a new and more comprehensive title. Fibre-to-the-Hub is probably a more appropriate description. Fibre-to-the-Home carries the connotation of a primarily consumer-market oriented network. This would be too narrow and would jeopardise financial viability and investor interest. In contrast, Fibre-to-the-Hub stresses the multiservice aspect of the network: the Hub can be a (Wifi-) router in homes, a mobile base station, a Hotspot that connects sensors or beacons, an in-building DSLAM etc. etc. It is becoming clear that an FTTH network is much more than just a last mile access technology for internet entertainment services. It is rather a system that provides data connectivity with the right quality and speed.

This perspective has important ramifications for the business case. Network capacity can be monetised in several ways as various customer groups will utilise the network. These can be larger corporates with redundant lines, SMEs which have an interest in SLAs, mobile service providers, utilities, media companies, public administration agencies, housing associations, individual consumers etc. Regardless of whether the network provider operates the network on a wholesale-only basis or prefers an integrated approach: the value of network assets increases with the desire to make cities and regions smart.

Below are a few case study examples:

Environmental control for citizens

A healthy sustainable environment is one of the most important factors for citizens as it is the basis for good quality of life. Many cities and regions are not able to control environmental factors, as they simply do not measure them as frequently as they should. And many of the environmental factors can be improved on relatively quickly, for example, rerouting traffic, changing traffic light patterns or just limiting traffic coming into the cities. The region or city can react to environmental challenges much faster and more cost efficiently if environmental data is collected and processed in a centralized data centre using fibre infrastructure.

Citizens leave rural areas

The trend over the past few years has seen citizens leave rural areas in order to be closer to their workplaces or move to cities where they can find a more comfortable living environment. Many regions suffer from this making it very difficult for them to maintain medical support, basic community support and other municipal services. In addition, most of the infrastructures in rural areas need to be renovated. This offers a region a huge opportunity to start building a new FTTH/B network while renovating existing municipal infrastructures. And also offers businesses and citizens more basic, affordable municipal support. Furthermore, broadband connections based on fibre can enable more specialised services such as telemedicine, which is especially suitable for the elderly. New FTTH/B networks generate additional revenue streams for the municipality.

Businesses depend on highly available symmetric broadband connections.

To remain competitive in a growing market companies need to scale up and permanently optimize their business processes and systems. A key success factor for an IT infrastructure using cloud services is that it must be based on a highly available, symmetric broadband connection. Recently businesses are relocating in order to expand and, to ensure support for future plans, they need the right broadband infrastructure in place. It is now becoming more and more difficult to sell space in business parks or land in a business area if a high quality symmetric broadband connection cannot be offered. This is driving excellent revenue opportunities for network owners and operators to deploy fibre networks in these areas.

Power utilities need to control demands of business and private households

Many governments have started funding programmes to help citizens deploy smaller renewable energy power plants on their land. This has had a detrimental effect on national operating power companies, as they still need to provide reliable energy supplies when demanded by the end-user. In the past month many

power outages have occurred due to either an energy shortage or too much in the power network. It is proving very hard to harmonize many smaller power plants with all the different renewable energy power sources; they do not provide consistent power as, for example, weather conditions are not static. Energy is hard to store and in most cases is lost once produced. To control demands a building also needs to become smart. There are multiple power sources in every home and these need to be controlled with automatic on and off switches, in addition, distributing power plants need to be connected using a highly reliable communication network to monitor their level of production at any one time. These technologies are new revenue streams for utilities and in turn for network operators as the utility can offer customers much more services along the demand curve.

Residential and Small Medium Enterprise users are driving for better services.

Today's businesses require much more flexibility from their employees; this translates into flexible working hours and availability during out of office hours. Also employees have begun to organize their private lives around their professional and therefore need additional services if they are to fulfil their duties from home. Many residential internet connections are now beginning to be used for working purposes leading to a different quality of service. In addition, a number of software products used by home workers or SME's are based on the "CLOUD", such as Office 365. Video conferencing for private and business purposes are becoming standard driven by the ease of use and end-user devices. Streaming services for video and music are common today and will continue to increase the amount of data sent over a network into a private home. As 4/8k TV's become more affordable for mass consumers IPTV will drive for additional data demands. Today, a typical household has three different TV sets.

Smart home applications allow end users to control access, light and heating remotely to their homes. Network operators have a great opportunity to generate higher ARPU's from customers using the bandwidth to support these applications; they are also ready to pay a premium rate for a good user experience.

Chapter 3: Business models

Network layers

An FTTH network can comprise of a number of different layers: the passive infrastructure involving ducts, fibre, enclosures and other outside plants; the active network using electrical equipment; retail services, which provide internet connectivity and managed services, such as IPTV and not least, the end users. An additional layer can also be included: the content layer, located above the retail services layer and the end users. This can be exploited commercially by so-called “over the top” content providers.

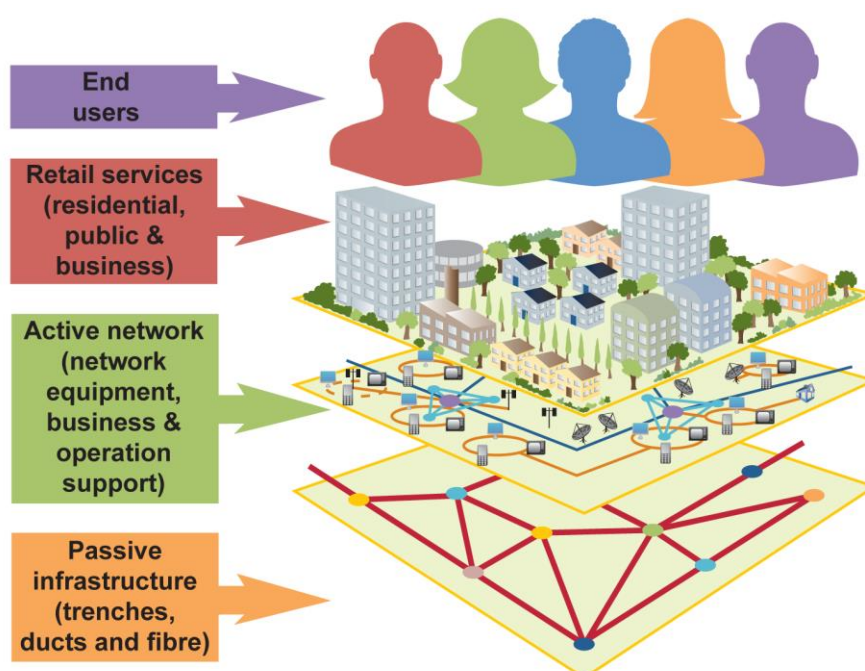


Figure 1: FTTH network layers (Source: Alcatel-Lucent)

This technological structure has implications in the way an FTTH network is organised and operated. For example:

- **Passive infrastructure** involving physical elements required to build the fibre network. This includes the optical fibre, trenches, ducts and poles on which it is deployed, fibre enclosures, optical distribution frames, patch panels, splicing shelves and so on. The organisation responsible for this layer would also normally be responsible for network route planning, right-of-way negotiations, and civil works used to install the fibre.
- **Active network** refers to the electronic network equipment needed to bring the passive infrastructure alive, as well as the operational support systems required to commercialize the fibre connectivity. The party in charge of this layer will design, build and operate the active equipment part of the network.

- **Retail services** become involved once the passive and active layers are in place. This layer is where basic internet connectivity and other managed services, such as IPTV, are packaged and presented to consumers and businesses. Besides providing technical support, the company responsible for this layer is also in charge of customer acquisition, go-to-market strategies, and customer service.

Each network layer has a corresponding function. The network owner is in charge of the first layer, although they may outsource its construction to a third party. The network operator owns the active equipment, while the retail services are provided by the internet service provider (ISP).

These three functions may exist as departments within the same company, or under the control of different organisations. Indeed, the same organisation could have different business models in a number of geographical areas, depending on the local market and the availability of potential business partners.

The traditional telecom model is based on “vertical integration”, in which one entity controls all three layers of the network. This is often the case for incumbent operators, for example, Orange in France, Telefonica in Spain and Verizon in the United States.

At the other end of the spectrum is the fully separated ownership of the different layers, as is the case in some parts of the Netherlands where Reggefiber controls the passive infrastructure. KPN runs and operates the active network and provides wholesale access; and various retail service providers including KPN, Telia and Vodafone, package the broadband and provide access to the services they offer as well as selling directly to end-users.

Possible FTTH business models include:

- **Vertically integrated**, which means one operator controls all three layers of the network. Consequently, if a second operator is interested in offering broadband and telephony services in the same area, he would have to build his own infrastructure, operate and market it directly to the end-user. This is a clear form of infrastructure competition.
- **Passive sharing** leverages a single passive infrastructure, which is built and maintained by one infrastructure owner. Active and services layers are owned by different organisations. A second service provider may share the same passive infrastructure with the first service provider, but would be required to invest in active network equipment and operations as well as the services and subscriber-facing activities.
- **Active sharing** is where a single organisation owns the passive and active infrastructure and operates the active network. This vertical infrastructure owner wholesales broadband access to various retail service providers who then compete with each other for customers.
- **Full separation**, as mentioned above, ownership layers are partitioned. Each layer is owned by a different party with the infrastructure owner generating income by providing passive infrastructure access to one or more network operators, who in turn wholesale broadband access to retail service providers.

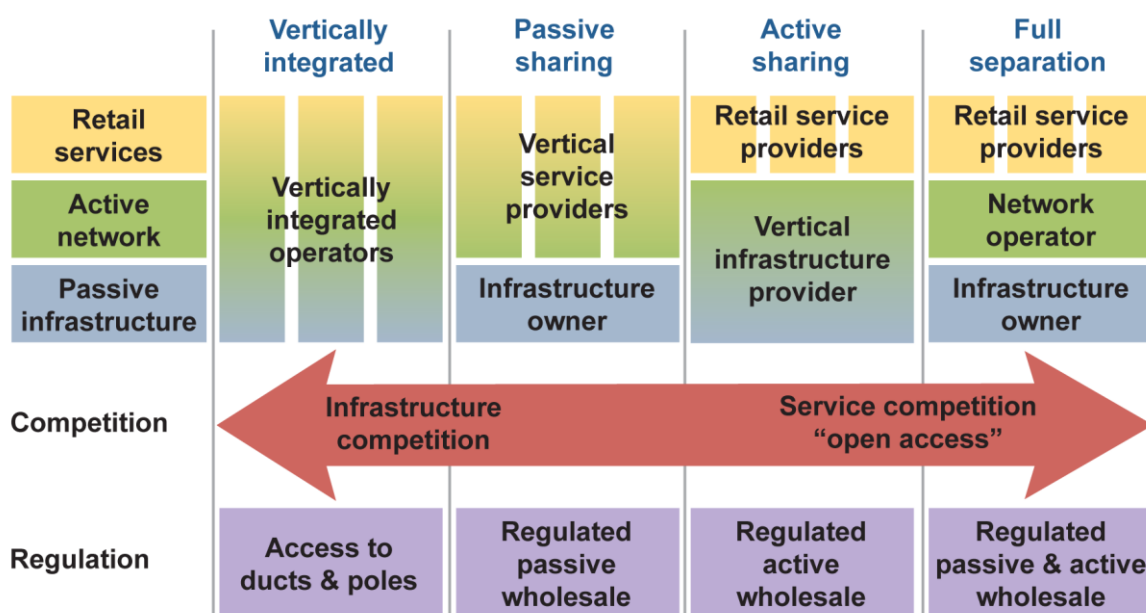


Figure 2: FTTH Business models (Source: Alcatel-Lucent)

The interest of an FTTH network owner could be contained in any one of the three levels in the value chain. Each type of business model has its own opportunities and challenges, which are summarized in the following table:

	Pros	Cons
Vertically integrated	Control total value chain and cash flow profile.	Complex operation and high execution risk.
Wholesale operator	Gains additional margins for modest incremental investment.	Must be technically credible yet flexible. Small operators may struggle due to lack of commercial and operational standards for wholesale.
Passive network owner only	Simple operations. About 50% of the revenue potential.	Lack of direct control over the revenue stream and marketing to the end-user.

Deciding which operational model to choose is fundamental as it determines the business model of the activities as well as the financial model. It is also very much dependent on local regulations, competitive environment and the core business activities and competencies of the organisation.

The existence of differentiated business models has opened up the FTTH market to organisations other than traditional telecoms operators, including electricity power providers, housing associations and local authorities.

Open Access Networks

The term “open access” implies a resource that is made available to clients, other than the owner, on fair and non-discriminatory terms; in other words, the price for access is the same for all clients and is hopefully less than the cost of building a separate infrastructure.

In the context of telecommunications networks, “open access” typically means the access granted to multiple service providers to wholesale services in the local access network enabling them to reach the subscriber without the need to deploy a new fibre access network. The wholesale pricing structure is transparent and the same for all service providers. Wholesale products are offered at different levels throughout the infrastructure based on the type of open access model:

- Passive open access infrastructure (ducts, sewers, poles, dark fibre, wavelength) offers telecommunications operators the opportunity to share a passive infrastructure and deploy their own infrastructures on top of delivering services
- Active open access infrastructure (Ethernet layer-2 and IP layer-3) makes it possible for service providers offering residential, business and public services to share a common active infrastructure that is built by a passive infrastructure player and operated by an active infrastructure player

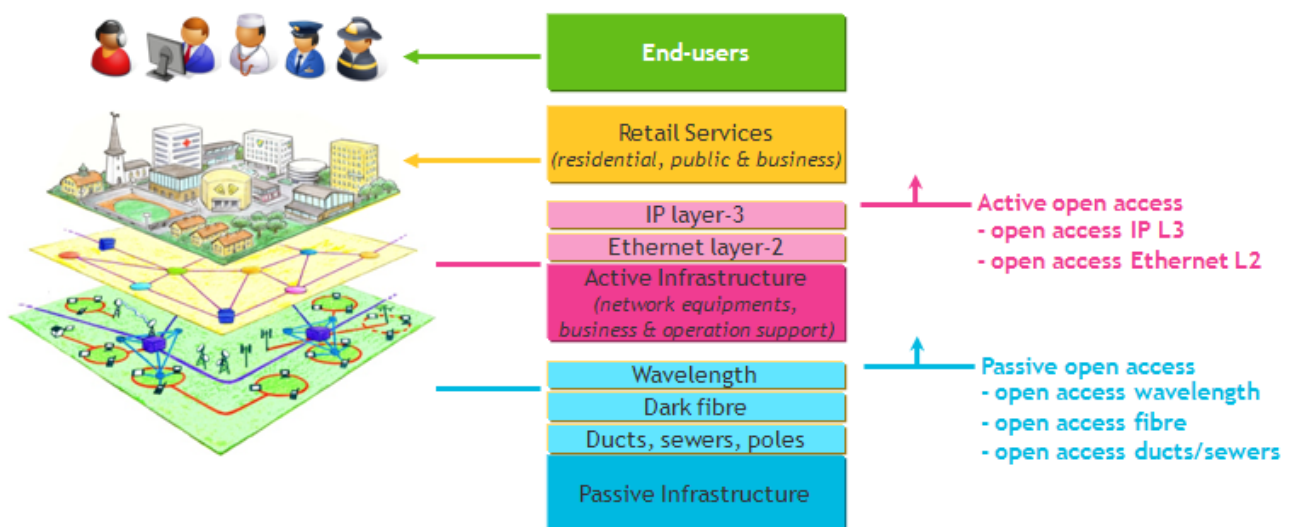


Figure 3: Open access models (source: Alcatel-Lucent)

Chapter 4: Project Planning

The complexity of starting up an FTTH project does not often get highlighted as much as it should. A small but dedicated team will be needed to establish the viability of the project.

Distinction should be established between planning, designing, building and operating an FTTH network. Different skills are required and therefore it is likely that people will need to be employed who have construction competences and others who can deal with the operation stage of the network.

Project timeline

The following diagram provides a visual timeline of the key stages leading up to the activation of the FTTH network and highlights the most important events during the planning and deployment phase.

1. Strategic Planning: making important decisions from a business perspective: What to invest? Where and when to deploy? How to design the network? What process to follow? What to outsource? How to fund the network? Answering these questions involves:
 - a. Demographic analysis
 - b. Cost estimations/Budget control
 - c. Coverage analysis
 - d. Demand Aggregation/Sales Process
2. Network Design: creating a to-build plan for the selected areas. This can include various steps, such as:
 - a. Initial High-Level Design
 - b. Field Verification/Permissions
 - c. Detailed Design/Engineering
3. Network Construction: the actual construction of the network, including
 - a. Civil works (including trenching, duct installation, access chamber construction)
 - b. Fibre Outside Plant (OSP) installation (including laying, pulling, blowing or hanging of cables, splicing of fibres, installation of splice closures). On completion of this step, the network is referred to as a “Homes Passed” network
 - c. Subscriber connection (including installing the last drop segment into the building so that the subscriber is connected). Once this step is completed, the subscriber is referred to as a “Home Connected”.
4. Network Operations, including
 - a. Network activation (including installation of active equipment at subscriber side, and the powering of active equipment at Central Office side). The subscriber is now referred to as a “Home Activated”.
 - b. Service activation: selling and activating the fibre services
 - c. Network Repair and Maintenance

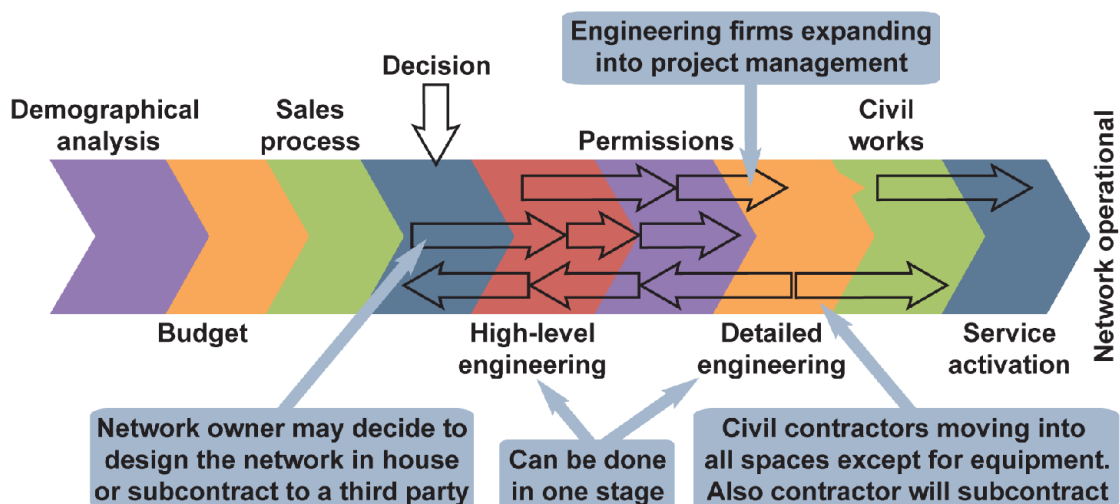


Figure 4: FTTH project timeline

1 Strategic Planning

When initiating the project, a thorough understanding of the local market, the potential subscriber base, the service provider competition, as well as the geography and existing infrastructure in the proposed deployment area are important. This information enables the network project leader to make an initial assessment of the situation and complete a business plan.

A checklist of actions:

- Identify all key stakeholders in the targeted deployment area, including potential suppliers, collaborators and end-users.
- From government sources (e.g. the Census Bureau or Office of National Statistics) acquire basic information about the market, including population by town/region and number of households. In some cases this information may be so detailed as to provide a breakdown of the population into those living in SDU's (Single Dwelling Units) and those in MDU's (Multi Dwelling Units). This information is extremely useful when estimating figure capital expenditure.
- Collate information relating to existing broadband provision in the region, especially in relation to availability, speeds and prices of current services. Service provider websites are an obvious first point of call. Where possible, determine if existing service providers have plans to enhance their product offerings. This information may be available through news sources or by approaching the service provider directly.
- The national regulator's website is also an excellent reference as data relating to current take up rates of broadband services is normally available. The regulator may also record more detailed information such as the penetration of different types of services, for example IPTV. A list of telecom regulators is available in Appendix B.
- Prepare a map of the proposed deployment area and try to identify the locations of the buildings to be connected along with the type of buildings (residential versus business, SDU versus MDU). Combine the geographical information of subscribers with the availability of local infrastructure, such

as roads, poles, sewers, spare ducts and so on. Based on this geographical information a project manager can easily derive accurate costs for the deployment, compare and identify most and least interesting sub areas, as well as comparing different technical scenarios for the construction of the network on the selected area.

- At this point it is advisable to ascertain potential subscribers :
 - what services are they interested in receiving
 - the level of service provided by their existing communications provider
 - what services they might be interested in purchasing and at what price, and
 - how their needs might develop in the future
- Conduct appropriate research, gather information regarding events surrounding similar contexts in other regions, lessons learned from elsewhere can either be fully adopted or adapted to individual situations.

1. 1 Demographic Analysis

Some key factors to consider in a demographic analysis:

- population density
- type of building, SDU's or MDU's
- household income
- average age in households and number of children living at home
- adoption of existing broadband services
- density of small and medium businesses
- presence of existing complementary or competing networks

If market research shows a strong demand for better broadband services, this information may encourage an existing operator into taking action. Indeed, this could be the desired result of a demand campaign. It should be noted that the response of other operators could impact negatively on a project as incumbent service providers will work hard to retain their existing subscribers, through the use of price reductions, improved services or even more devious tactics.

Some FTTH projects have experienced legal challenges from other operators, which can cause substantial delays in launching proposed services. Such delays can also extend the time needed to achieve positive cash flow, have a detrimental effect on borrowing costs, as well as the addition of legal expenses. To the extent these challenges can be avoided or dealt with expeditiously, the road to positive cash flow is likely to be achieved faster.

A thorough and detailed demographic analysis (together with sales activities based on the analysis) will help boost subscriber penetration of the network.

1. 2 Cost Estimations

In the strategic planning phase it is also crucial to obtain an accurate view on the required budget for realising the network. But the cost of the project will be influenced by many factors and while making

decisions, a project manager should also try to understand how different choices will influence the cost of the project.

Some important variables are:

- chosen business model – from network owner to fully integrated operator
- choice of topology – point-to-point or point-to-multipoint
- choice of technology (or mix of technologies) – point-to-point, active Ethernet, GPON, XGPON, TWDM-PON
- size and locations of the POPs and intermediate fibre aggregation points
- cable route – pavements, asphalt or soft dig
- cabling strategy – buried cables, aerial cables, or a combination
- commissioning strategy – fibre outlet in the household, in the street outside, duct already installed or drop box within a given distance
- cost of the equipment to light the fibre
- both capital expenditure and operating costs must be taken into account
- sales costs

Based on geographical maps of the entire area, automated network design calculations can be used to derive an estimated Bill of Material and Bill of Quantity. This will enable an estimation of the costs of the entire project, or even per neighbourhood. And by varying the design rules at the input of the calculation, one can derive the cost per technical scenario and thus estimate accurately the impact of every possible choice on the expected budget. As such, a project manager can easily compare options and make the optimal choices, being fully aware each time, of the impact of such choices on the required budget.

1. 3 Coverage analysis

When combining a demographic analysis with a geographical cost calculation, it is easy to perform an analysis on a neighbourhood level that will compare the costs and potential revenues per neighbourhood. This analysis will provide a good indication which areas might be excluded from the project or which are most interesting and should thus be treated first on the rollout list.

1. 4 Demand aggregation

The initial budget, together with possible revenues indicated by the demographic analysis, will offer a realistic progression to the next stage. Assuming an overall “go” decision, a business plan and secure funding for the project must be in place.

A minimum percentage of signed up subscribers in a given area ahead of construction is strongly recommended. Registering subscriptions in advance of network rollout is a common strategy among FTTH operators. Based on the geographical cost and revenue analysis per neighbourhood, one can easily determine a good “trigger” level (percentage of households that pre-register for the fibre connection) for each area that would be recommended before starting the network deployment – for example in some areas the figures could indicate that digging should only start when at least 40% of households in the connection area have pre-registered for services.

An awareness-raising campaign outlining the advantages of FTTH to potential subscribers can help to stimulate demand and increase sign-ups. This could be an important strategy as potential subscribers are largely unaware of the benefits of FTTH, or even of the type of broadband connection they are currently using. This is partly due to service providers who often sell broadband products using a brand name, such as Verizon's FiOS. Further confusion arises as some broadband products based on cable or VDSL technologies are branded as "fibre optic", even though fibre does not extend from the neighbourhood into the home.

A number of key sales considerations:

- a business model for revenue sharing should be complete before starting the sales process
- price used to attract early adopters; however, limit extent of any possible connection fee offers
- do not underestimate the installation time
- sales results should steer installation schedule
- specify demand registration targets: one for starting the design and the second for entering into right-of-way agreements
- services must be ready at the same time as connectivity; there is limited value to the end user otherwise
- streamline installation activities to limit time from sale to connection as short as possible

2 Network Design

2.1 Initial Design

During an initial design phase the network planner will try to consider all aspects specific to the area and propose an optimised network plan that complies with the general design rules.

The objective is to minimize the costs by making optimal choices for the location of fibre aggregation points and routes of cables, considering:

- available infrastructure to reuse such as ducts, poles,
- available cable, duct and closure types – select the appropriate set of materials according to the specifics of the area
- fibre needs per demand point (some buildings may need more fibres, or may need P2P as opposed to P2MP connection)
- redundancy – the existence of multiple paths in the network in case of failure
- demarcation points between the subscriber and end-user
- rights-of-way

Constructing an initial design is often carried out in-house by the operator or investor as this is an ideal verification of a detailed design in case such detailed designs are outsourced. A project manager could immediately see if a detailed design would be much more expensive than the initial design and ask for additional analysis to investigate where the detailed design could be further improved before taking the network into the construction phase

2. 2 Field Verification and Permissions

Initial choices on the design will need to be verified: can a cabinet or manhole be installed at the theoretical optimal location or does it need to be relocated? Can a cable cross the street at the indicated location?

The right-of-way process should be considered early on in the project, as should the involvement of the local inhabitants in the actual area of deployment. This action will also support the sales process and minimize the number of objections. In addition, the support and official backing of the project by the community and political leaders is vital.

This process not only includes negotiating rights-of-way and network maintenance, it also involves finding spaces for POPs and cross-connection points.

Some important issues are:

- contracts should correlate with the expected lifespan of the network
- avoid gatekeepers – organisations or individual that can hold the project to ransom by threatening to cut off the network from the outside world
- do not be afraid to rethink the design

Based on a field survey input and obtained permissions the initial design can be adjusted in order to fine-tune the design into an optimised plan taking into account all constraints from the field.

2. 3 Detailed design

Detailed Network design may be carried out either by the network owner or the contractor, depending on the strategy chosen for the purchase of construction.

At this stage, the intention is to design a detailed and fully documented to-build plan, including labels, fibre connection plans and logical network plans.

Some key considerations are:

- detailed design should be clearly documented
- plans should be easily transferred to the field team and clearly describe how they should build the network
- workflow management needs to be linked to the construction plan so that construction can be easily followed
- Plans should be easy to update in case the actual construction differs from the plan

For this part of the FTTH project, the business case can be solidified by embracing the existing Design and Networking inventory software solutions. These solutions can bundle the design effort, take into account the design rules, hardware and equipment pricing, the network inventory and labelling and generate a detailed design, as-built design and even a to-build design.

The output of these solutions is often reflected in a very detailed and accurate Bill of Material, which can be used for the civil works and act as a guideline for the construction companies and contractors.

Note that good preparation at the construction phase by collating detailed geographical information about the area and including field surveys and fine-tuning of the design as described above, should result in a minimal difference between the final to-build plan (the result from this detailed design step) and the actual constructed network that should be documented in the inventory system for supporting the operations of the network (as-built plan).

3 Network Construction

Even though fibre infrastructure can be considered high tech, most of the costs are related to digging. Therefore investigate methods and materials to minimize digging and work on site with the aim of reducing the total cost.

A major issue is actual access to homes, particularly MDU's (Multi Dwelling Units). Installation often requires co-ordination where several individuals have to provide access to their homes to support a sequence. This together with the handling of keys often disrupts the installation process and results in unexpected costs.

Some key issues are:

- ascertain scope of the work if going for lump sum offers
- if working with open books, partner with the contractor early and maintain good cost control
- secure quality of contract documentation
- indoor and outdoor activities may require different engineering competencies
- use the construction phase as a marketing opportunity: take advantage of the occasion and correlate sales activities to the roll out

4 Network operations

Activation phases cannot start until a complete link is created from the end user to external networks. Depending on the business model, this activity could be handled by the network owner, a communications operator or a telecom operator. It is important that documentation is correct and that sales activities have been consolidated in a system that also supports commissioning.

The network is of no value to the end user and will not generate any income for the service provider until it is activated and filled with services that can be used. Services should be available at the same time as the connectivity. A network with pre-installed outlets makes remote commissioning possible and decreases the costs of connecting subscribers.

Customer Support has to be in place as soon as there are paying subscribers on the network.

Some key issues are:

- physical installation takes time
- active equipment at the user end is needed but will create support costs
- clear demarcation points between different parties (network owner, operator and service provider), should be in place for the benefit of the subscriber
- the party with subscriber contact should handle front line support
- in a multi-service network, a single source of front line support may be separate from the services

Chapter 5: Services

Services are enabling your business

Executive Summary

What type of services will be available over the network? Whilst in the past the FTTH network infrastructure has been the focus of the operators and providers by offering more and more bandwidth as a means of increasing revenue, now a major change of focus is apparent. The FTTH network with its active and passive components functions as the stage for dynamic growth in the variety of services and applications which are enabling new business and revenue sources for the market players in Europe and across the world.

The key questions for all types of FTTH organisations is how to generate additional revenues and what kind of business case allows a fast return of investment? The answer to both is to provide a continuous array of new services - whether they involve network owner, wholesale operator, or retail service provider. If the FTTH organisation does not plan to operate in the retail service layer, it will need to establish relationships with companies that will offer services and applications.

In general, today's services and applications can no longer be seen as standalone solutions as they were previously (for example, the classical triple-play for residential users). A service is now described as being a continuous developing group of applications, whether for residential, business or public consumption. These applications are able to communicate or interact with other applications from the same service layer or they are able to "cross-talk" with applications from other service layers. Finally the interaction between service-layers, applications, sensors, computer devices and machines result in a new industrial revolution which started a couple of years ago and is going faster and faster into the future. The internet of things (IoT) and Industry 4.0 are now becoming reality.

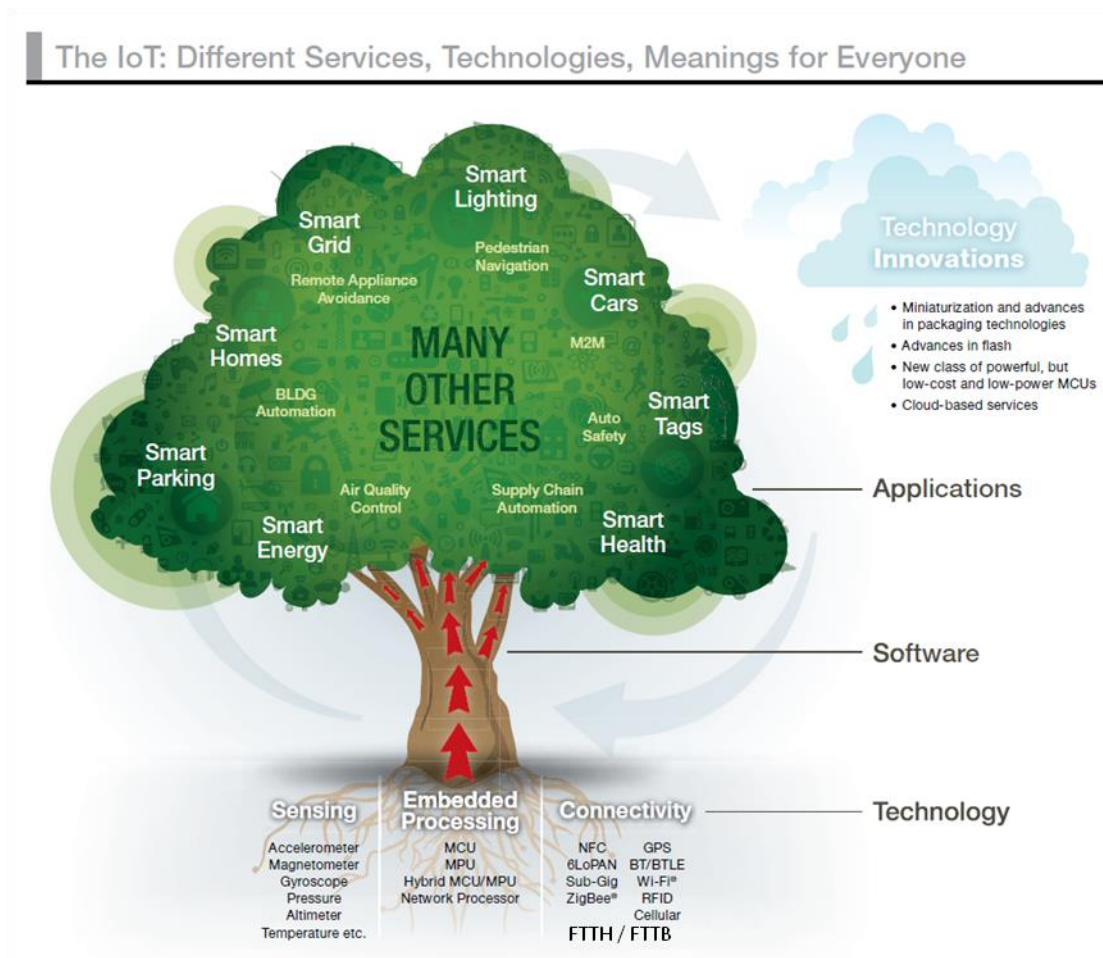
The evolution of services and applications is closely linked to bandwidth availability and the positive affect these services and applications have on each other. New services and applications spawn new revenue sources, encourage adoption of new devices, change end-user behaviour and drive the need for increasing bandwidth capacity. Expanding bandwidth capacity will allow for the accommodation of additional content, encourage application growth and spur new services and applications. The door is opening for almost unlimited business opportunities.

Delivering fast bandwidth is a profitable product but delivering services and applications on top will be a much more profitable product for FTTH network owners, operators and service providers.

The internet of things (IoT)

The interaction between services, applications, sensors and computer devices becomes ever more real and offers new revenue sources with huge potential. On the one hand we have a consumer-driven market

focusing on the connected home, connected car, entertainment and all matters relating to health and education, and on the other hand, a business-driven market with its focus on industry, cloud and security.



[Source: Freescale / ARM 2014]

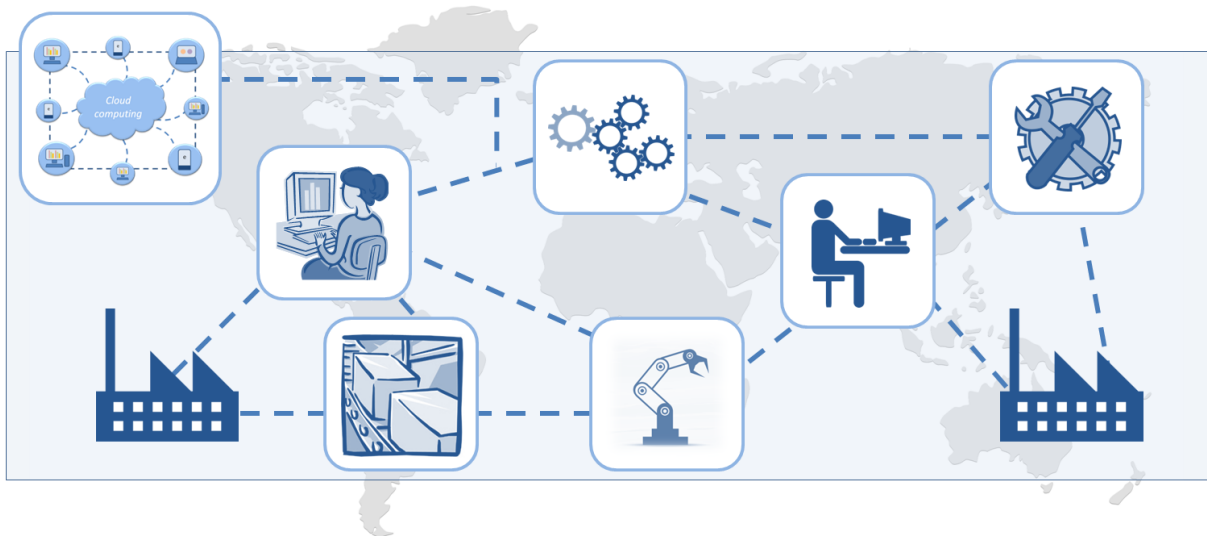
Reprinted with permission from NXP Semiconductors, 2016.

The keys to the IoT are the installed units with IP connectivity. These units are communicating without any human interaction and working mostly independently: IP cameras, sensors and machines for example. The research analyst organisation, IDC, claimed that at the end of 2014 there will be approximately 9 billion IoT units worldwide installed and by looking into the near future, it is expected that by 2020 there will be an estimated 28 billion installed IoT devices worldwide. Furthermore IDC states in its 2014 study "The value of IoT", that the worldwide revenue for services and IoT technology will increase from 1.9 Trillion USD at the end of 2014 up to 7 trillion USD in 2020 at a 20% CAGR.

Those facts and figures will only become reality when a continuous rollout of FTTH networks are guaranteed; especially within the European Union, where the historical copper driven infrastructure is nearing its limits.

Industry 4.0

The 4th industrial revolution - as the industry 4.0 is known - and the internet of things (IoT) are directly cross-linked. The IoT allows the ongoing virtualisation and decentralisation of manufacturing processes through all types of industry. Smart factories and humans are able to communicate with each other via the IoT while the advantages of real-time capability and modularity are allowing a flexible adoption of changing requirements and replacing or expanding individual processes. Examples for industry 4.0 are machines that can predict failure and trigger maintenance processes autonomously or self-organised logistics which can react to unexpected changes in production.



Industry 4.0 with all its aspects and parameters allows a demand driven and cost efficient production process, such as a virtual construction office that is capable of triggering a smart factory into manufacturing products. Due to the fact that the virtual construction office does not need to own machines and by selecting a low priced production plant, companies are able to reduce costs and gain competitive advantages - worldwide. However, the areas most affected by industry 4.0 will be:

- Service and business models
- Reliability and continuous productivity
- Product life cycles
- Workers
- Industry value chains

By mapping the IoT and industry 4.0 it is obvious that there is an urgent need for ultra-fast bandwidth that is only possible via FTTH networks; in addition, it is those technology trends that offer huge revenue potentials for network and service providers. So the emerging need for a nationwide fibre infrastructure in Europe is once more apparent.

Business model for FTTH services and applications

Generally it is not only the number of connected subscribers which makes a sound business model for FTTH networks, it is also the number of services per subscriber which enables revenues and the quality and attractiveness of those services and applications. For example a customer is more willing to pay for TV services when 4K or 3D content is offered or when he gets high quality sound (HQ) VoIP services.

Furthermore, the number of offered services and applications could be a crucial factor - a provider who offers only a handful of packages could be less attractive to the customer than an OTT service provider who is able to offer a wide range of high quality services and applications.

So the key is the revenue per user that must or should be achieved. The average revenue per user (ARPU) acts as an important measurement when planning an FTTH business case. However it is not only the ARPU; at the end of the day it is also the margin levels. When planning the business model for services and applications, much consideration must be given to the origin of the content. Is the operator or network owner able to deliver (produce) those services by themselves or is it necessary involve a third party who will buy the application and service packages? Admittedly, the margins would be higher if the content was directly created by the operator or network owner but if the quality is below standard, then the customers will not be willing to pay for it. However, if the content comes from a 2nd vendor, the margins could be lower but the quality satisfactory and the customer are willing to pay extra. Therefore it is important to find the right balance between sources, quality and price.

When looking at the bandwidth capabilities of an FTTH network there are great opportunities for service providers - value added services capable of generating new or additional revenues.

Residential FTTH services and applications

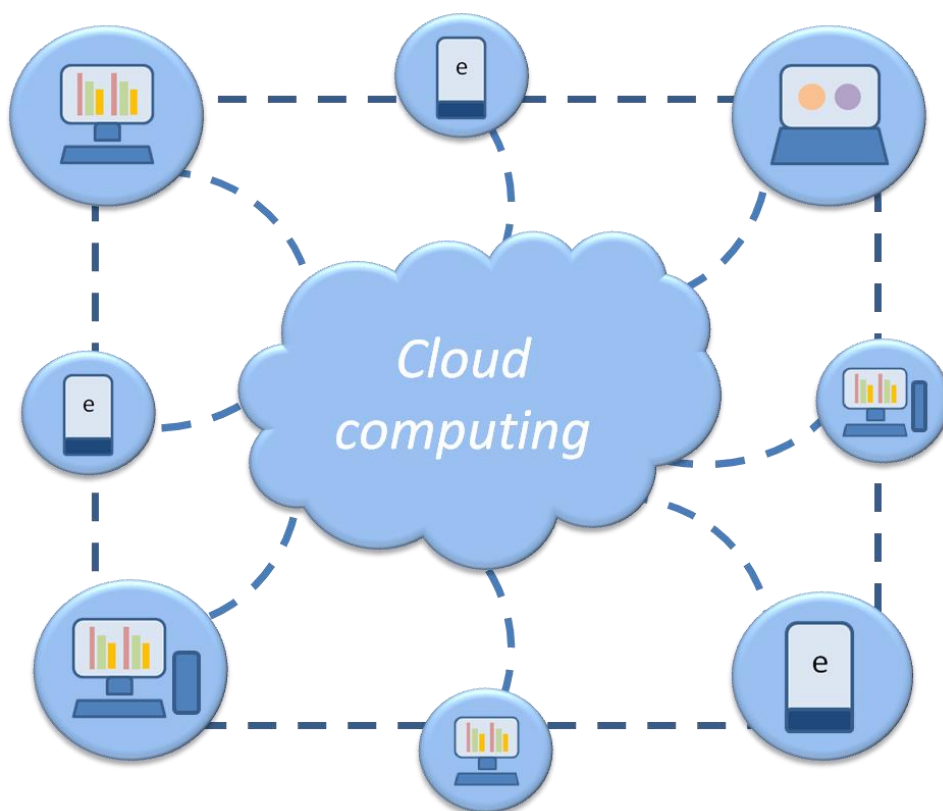
In the past typical services offered to the residential subscribers included simple triple play packages (VoIP, Internet, TV). Today most operators go beyond those basics and offer services and applications which differentiate the individual operator from the competition and create increased revenue potential. The most common services and applications are web-space, online-backup, gaming, home surveillance and others, which could be offered as standalone apps or as dedicated packages. A fast internet access via fibre is the door opener for increasing internet activities such as online shopping, online banking, education, online public services, catch-up TV, HD and UHD TV, online gaming, smart homes and much more. If the network owner or service provider is not able to deliver services or only a limited number of services, one possibility could be partnering with a 2nd or 3rd party. Retail ISP's may also choose to offer on-top services or possibly specialized service packages. For example:

- A housing association-owned network might offer a central system for maintenance services or infotainment
- A municipal network might offer local TV broadcasts or public services, such as digital urban administration services
- A utility might team up with the network owner - or provide its own FTTH network - and offer CATV over fibre or an integrated system to implement smart grid and smart home services

Business FTTH services and applications

Almost all large enterprises are already involved in fibre optic networks as the high bandwidth, high reliability, symmetry and high security requirements far exceed those available in the residential sector. As a result of special requirements, these large businesses are not usually linked directly to the same infrastructure as residential subscribers. However, research has found that there is a considerable market opportunity in addressing the under-served lower end of the business market. Small and medium sized enterprises (SME's) can easily be served from a typical FTTH network, even if the network is subscriber-focused. A discussion with any business located within the coverage area may be advantageous.

The technical network requirements for businesses may not be substantially different from those for subscribers. Business users may be interested in tailored service packages involving extra features such as uptime guarantees, lower contention, higher security and business-grade customer services. A discussion with local businesses to assess their needs is advised.

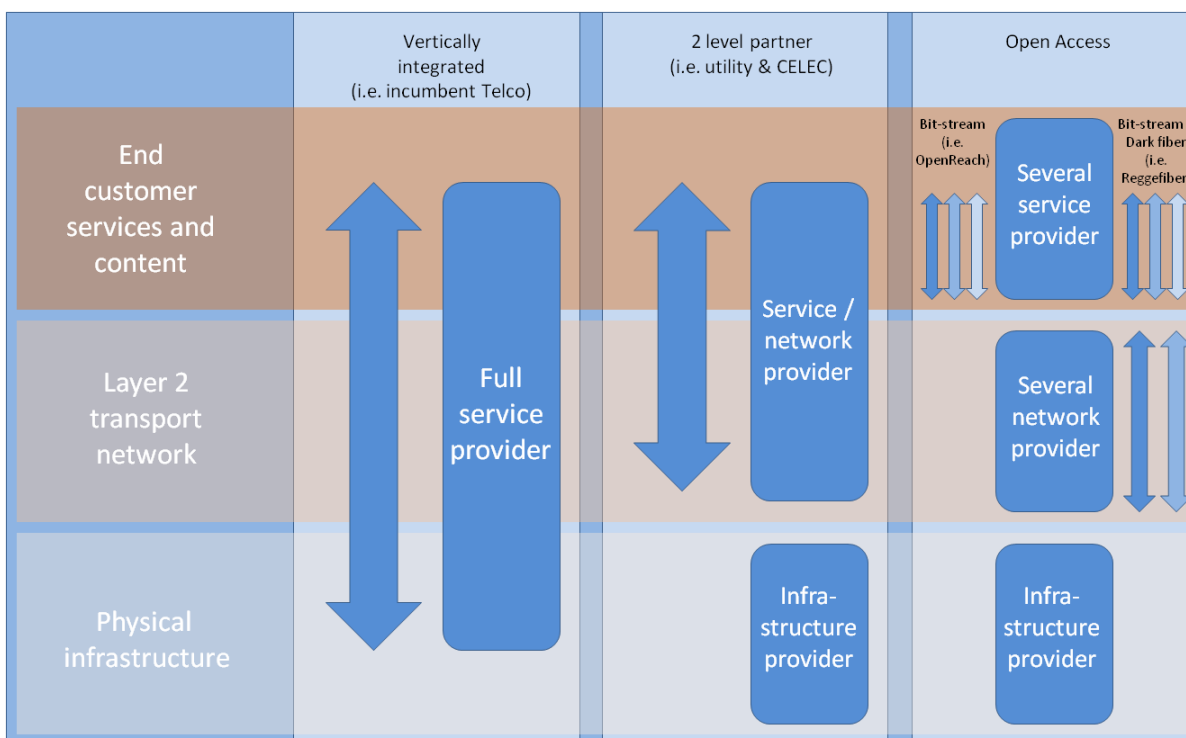


Cloud services and application outsourcing are becoming popular with businesses, as they create genuinely new methods to reduce operating costs (OPEX). Although available bandwidth is an important network requirement for cloud services – it is not the only criteria. In cloud computing, where information can be stored anywhere on worldwide existing virtual server locations, low latency is one of the critical requirements. FTTH technologies fulfil these requirements and offer guarantees to the operator against a cycle of network upgrades. Further service provision opportunities may exist that require features only deliverable through fibre networks, for example:

- Video conferencing and tele-presence are complementary to business services
- High-frequency trading where participants need lowest latency connections to stock exchanges
- A Virtual orchestra where musicians need low latency connections to colleagues residing in remote places. A possible model for the professional music recording business.

Carrier FTTH services and applications

Studies suggest that Open Access policies, which allow third parties to offer their services on the network, can enhance the business case, particularly involving new parties in the retail market place. Attracting established, respected, internet service providers to offer products and services over the network can be an effective means of increasing overall market penetration.



A good example of an Open Access approach is Suupohja in Finland (Successfully Bringing Fibre to Rural Finland). The municipality-owned network is available to all kinds of internet service providers (ISPs) at no cost. It enables the FTTH rollout and socio-economic boost for a region where the population density is 87% below the European average. A full report of this and other case studies can be downloaded at our FTTC council website: <http://www.ftthcouncil.eu/resources>. In this case, Open Access functions as a service and application enabler as bitstream allows multiple service providers to offer their products on one physical network. Users can select one or more service providers and design a service package that suits their own particular needs. Open Access is one possibility for all involved players to generate new OTT revenues, for example, the local utility provider offers a dedicated smart home package and one of the service providers is specialized in entertainment - by offering 4K TV content or gaming packages. This kind of virtual tool box

opens up a wide range of different applications and services which could be individually selected by the connected subscribers.

The rollout of optical fibre into the access network on a greater scale offers additional advantages for other networks such as mobile. Mobile broadband currently offers download speeds of up to 100 Mbps to users through such technology as 3G LTE. The next generation of mobile broadband based on 4G LTE advanced is currently being rolled out and has the potential to offer 1 Gbps or more. But that's not all – the first 5G LTE trials with 20 Gbps are planned and the first commercial rollouts are foreseen for 2018 – the need for speed never ends. An additional return of investment will be possible for the network builder who takes this added dimension into consideration.

Public sector FTTH services and applications

The public sector sites should not be neglected when drawing up FTTH network plans. Schools, libraries, hospitals, clinics and local government buildings all require connectivity and have expanding requirements. With the growth of ICT in school curriculums, libraries becoming digital access points, doctors sharing patient records digital and governments offering an increasing number of public services online. These organizations can become anchor tenants on the network. The following provides some examples from the public sector which are based on ultrafast FTTH broadband technology:

- **Telemedicine:** telemedicine is the primary application for broadband, it could be used for remote diagnosing, purchasing medical supplies and prescription drugs online, remote monitoring, etc.
- **Teleworking:** saving on commuting expenses, reduced office space, collaborating on project more easily, enabling persons with disabilities to work, higher employee satisfaction, etc.
- **eGovernment:** getting information through self-service online - lowering the cost of providing services, for citizens it lowers time by reducing number of visits, less waste, fraud and abuse.
- **Distance Learning:** opportunity to learn without the burden of costly and time-consuming travel to educational institutions, specialized subjects do not require physical presence, collaboration on group projects when participants are geographically separated, etc.
- **Public safety and security:** biometrics screening at designated entry points, remote surveillance of sensitive facilities, off-site support during disasters, etc.

Financial metrics

ARPU (average revenue per user) is the correct term for the average monthly revenues paid by a subscriber. The higher the ARPU in the target market, the more attractive that market will be. Broadband pricing is influenced by a range of factors, including geography, demographics, competition and possible regulation. The business community and the public sector will generally support different pricing than retail consumers. Many incumbents have conducted pre-launch market studies that have tended to suggest that residential potential subscribers would willing to a 10-15% premium for a triple play subscription over fibre. In areas where there is a strong satellite TV offering this figure may be lower.

MARGIN is the key for a successful business and fills at least the coffers. Offering service packages and applications with low or near zero margins is a high risk for the whole business case as those on top will

make the future money for a profitable business. Therefore it makes no sense at all if there is an ARPU but none or very little margin. The right balance between quality, attractively priced services and costs must be achieved. A study into NGA product portfolios commissioned by the FTTH Council Europe identified several retail strategies. The Yankee Group analysed the service portfolios of 20 NGA operators around the world in order to identify the kind of services currently offered: the attractiveness, relative profitability and technical requirements of these services – as well as the directions in which service providers are developing or proposing to develop new services in the future.

Research has shown that the business case for FTTH is highly sensitive to subscriber take-up services. The choice of service packages and the ability to provide these and future services has been one of the main criteria for success or failure of independent FTTH networks. In a separate study, the Yankee Group showed that penetration rather than ARPU has the strongest effect on the FTTH business case. The set of assumptions used in their model, made it difficult to create a business plan with a payback period of five years or less, unless penetration reached at least 30%. By looking to the offered service packages, market segments can be divided into three segments:

- Basic services; Triple-play services
- Basic triple-play services + safety + value added services (VAS)
- Basic triple-play services + safety + value added service (VAS) with customised solutions for individual customer

How much market share is it reasonable to expect? Experience indicates that first year penetration rates in areas with no fibre, cable or fast xDSL competition, such as VDSL vectoring, can be as high as 50%, but 20% - 30% is perhaps more realistic. The final penetration in the same area might be as high as 70%, but again estimating the realistic penetration will also depend on the ability and willingness to pay.

The competitive environment will be the major influence in the size of an expected achievable market share. The maturity of broadband and triple-play local markets varies greatly across Europe. Greece for example has only had affordable broadband penetration with cable television and ADSL since 2008. Whilst in Sweden, a large number of areas where FTTH and cable compete has resulted in the exclusion of ADSL on the market.

In general, it is easier to gain traction in a growing market, although it is also entirely possible to convert a local market from lower broadband speeds to high speed broadband. Places not currently served by broadband clearly offer the best prospects – however, broadband “notspots”, which are locations too far from the telephone exchange to receive DSL services, tend to be geographically remote and therefore more expensive to connect with fibre. The most risky proposition is a market that already has a good FTTH coverage. All other factors being equal, the presence of an existing FTTH operator immediately reduces the addressable market by 50% - why should a new provider expect to get more than a fair share of the market? In reality a new provider is most likely to be competing for the unaddressed portion of the market and consequently also facing a much harder sell. If they didn't want fibre from first service provider, why would they want it from a second?

Conclusion

The business case for FTTH and also the future growth of this technology will be dependent on the revenue and its growth rate. New streaming services such as 4K / 8K TV and emerging low latency products (IoT, Industry 4.0) are demonstrating that a copper based infrastructure has reached its limits and must be replaced/upgraded to pure FTTH networks. Furthermore, in order to increase the revenue stream for the deployment of FTTH networks, services and applications, the following needs to be exercised:

Enhancement of value added triple play services:

Deployment of creative and innovative applications and services over the usual triple play services of voice, video and data. This will add to the experience of the service and enhance revenue.

Integration of new value added services:

Looking at present-day requirements, it is possible to sense the need for a lifestyle change by the subscriber – FTTH can be likened to building a six lane motorway to the home – the subscriber is looking for next generation applications and services in bundled form. Convergence is occurring in every aspect of the solution, therefore it will be necessary to integrate intelligent home solutions and automations to FTTH offerings. They will then act as a “booster” application for FTTH and contribute to revenue growth and future scalability of the same.

Chapter 6: SDN and NFV for FTTH

Introduction

Software Defined Networking (SDN) and Network Functions Virtualization (NFV) are generating significant interest in the telecommunications industry due to the promise of creating extremely flexible networks that can be adapted to the needs of the services being carried as well as to needs of the subscribers being served. However, thus far, the emphasis of SDN and NFV has been associated with application in the Data Center and the WAN, with little consideration of applicability to FTTH networks. However, the principles of NFV and SDN can be extended to FTTH networks, making them more dynamic and responsive while providing operational benefits.

The principles

The SDN paradigm stipulates the separation of control and data plane, as well as centralization of control functionality. This allows hardware and software to evolve independently of each other and decouple the innovation cycles. SDN has been gaining momentum as it allows network operators and subscribers to exercise more direct control over the paths taken by the packets. This helps networks respond to changing demands more rapidly and better align with the needs of the applications running on top. The activity around SDN is complemented by network functions virtualization (NFV). NFV addresses today's rigid, vertically integrated architecture of network devices. The promise of NFV is the separation of network functions from specialized hardware in order to enable mobility of network functions and to stimulate rapid deployment of new functions.

NFV affords new IT-like agility to on-board, scale and shift resources to accommodate changes in network demands and requirements. This optimizes the use of network resources while significantly reducing the time it takes to introduce and ramp up new services.

Some network functions are well suited for execution on commercial off-the-shelf servers while other data plane-intensive network functions are not suitable for migration. The virtualization of network functions will bring most benefit when combined with SDN control and orchestration mechanisms to link virtual network appliances and hardware network elements into a service chain suited to network subscriber needs.

The accelerating pace of service innovation and the shift to cloud services increases the dynamicity of network traffic and raises the importance of having a responsive and adaptable underlying network. An access network without programmability afforded by SDN and flexibility of network function virtualization will not be able to fully utilize network resources and will impede the introduction of new services (especially the dynamically changing cloud-based services).

SDN in context of FTTH

In its most basic form aimed at data centres and WANs, SDN is based on the separation of the control plane from the forwarding plane with a control protocol used to change the behaviour of the forwarding plane. This goes hand in hand with abstracting the complexity of access networks. Seldom should the network operator need to face the network's full complexity. Simplified means of control will be able to establish end-to-end connectivity according to higher-level policies and enable the reliance on lower-level automations. It is the SDN controller that has a broad view of the network and can optimize the flow of traffic to improve the performance and utilization of the network. In the context of fibre access networks, the steering of packets in the network has less relevance as traffic paths are largely predetermined by the tree topology. The more important aspects are:

- the automation of hardware provisioning, and
- the programmability of features governing the behaviour of network devices.

These aspects are especially important in the environment in which more modular & distributed software architectures will be adopted. Herewith, the programmability of the network is relying on open interface communication between SDN controllers and network elements from multiple independent vendors. Consequently, this transformation places emphasis on supporting configuration protocols and standard equipment models.

While the disaggregation will migrate certain control functions away from FTTH hardware to software controllers, the end goal of the transformation is to improve the overall performance of the fibre access networks. It can therefore be expected that the functionality relevant to packet forwarding plane, such as physical interfaces, MAC, switching and traffic management will remain tightly integrated in hardware elements. It is expected that the rich configuration interfaces and the visibility of the global network state of the controller will bring the primary benefits of SDN-enabled programmability

Network access use cases

There are many imaginable SDN/NFV use cases. Below are some examples leveraging the automation and centralized programmability that are relevant to fibre access networks.

Virtualization of the home environment

Providing CPE and supporting residential services is costly especially as service providers have a plethora of different CPE solutions in their network. Virtualization of CPE functions can provide a significant reduction in CAPEX and OPEX. This can be achieved through simplification or elimination of equipment within the home, by extending the life of CPE devices, and by providing SPs with visibility of the end user LAN for maintenance purposes. Virtualization of the home environment eases new service introduction as CPE functionality and user installation is minimized.

Access network virtualization

Network virtualization or “slicing” is an SDN use case in which a single physical network is partitioned into multiple virtual network “slices”, each of which can be independently controlled to address the specific needs of building bespoke networks.

There are several applications of network virtualization including:

- Open access - Multiple Virtual Network Operators (VNO) use shares of a common physical network. SDN can realize open access through virtualization and slicing of network resources. Traffic flows, representing services between each provider and their end customers, are defined in the central controller, bound to specific policies, attached to resources, and measured at service time. Slicing can be achieved by providing network abstractions presented to each operator as an SDN programmable infrastructure. Policy constraints will determine the level of control available to access seekers enjoying physical unbundling, while ensuring logical separation of traffic and configuration between tenants.
- Service partitioning - Independently managed slices of the network for different types of services (enterprise/residential/mobile backhaul/VPN, etc.) with greater granularity and dynamicity than engineered partitioning. One such network service requiring dynamic reconfiguration is the transport of next generation 5G wireless network traffic. 5G are expected to bring much denser deployments of wireless access points and base stations offering greater opportunities in unifying the transport infrastructure of wireless and wireline access. However, the requirements for transporting 5G traffic dictates low latencies and high throughput. For wireless traffic to reliably share link capacity with residential network services, network element functions will need to be dynamically reconfigured in response to changing traffic patterns.

Capturing the value potential

SDN & NFV are invariably portrayed as the key instruments to lower the network’s total-cost-of-ownership and serve network traffic growth profitably. However, what is likely to be more significant is their ability to generate new revenue streams for network operators.

The main drivers are:

- Transformation of the network architecture model towards a cloud-optimized solution.
- New services: Granular network slices allow operators to provide new and customized applications to different users, potentially creating a larger portfolio of enhanced and highly customizable digital delivery services and associated revenue opportunities.
- Rapid deployment: it provides operators with the ability to rapidly and inexpensively deploy, configure, launch and upgrade services, leading to a time-to-market advantage. It also reduces the business risk associated with new service introductions. This agility allows operators to offer trials of new service offerings on a much larger scale (and to rapidly modify such trials as needed), leading to acceleration of new revenue generation.

- Elastic scaling: Operators can scale virtual network function capacity in line with the demand and requirements of specific use cases. The ability to provide existing services dynamically on demand should lead to a price premium relative to that of a statically provisioned service. It also enables addressing subscribers for which a rigidly defined service offer is not cost effective.
- New business: The ability to provide network connectivity services at granular levels consistent with current demand enables operators to penetrate new market segments. Granular offerings also attract smaller subscribers (for example, xVNOs, small rural operators, M2M providers and enterprises) who cannot afford to invest in the full-scale traditional FTTH architecture for these functions.

Ultra-dense fibre broadband networks

Expanding traffic volumes and, more importantly, increases in access bandwidth offerings require network elements to be placed closer to subscriber premises and ultimately provide fibre rolled out into-the-home when it makes sense economically. For ultra-broadband FTTx networks with the last mile on copper, means that the distribution point units (DPUs) must be within a few 100 meters of the subscriber. Multi-System Operators (MSO) with Hybrid Fibre Coax (HFC) networks and mobile operators face similar challenges. As the distance decreases and the data plane and PHY functionality move closer to subscriber, the number of aggregation devices dramatically increases.

This shift from centralized to highly distributed access network elements introduces many more NEs in the access network, increasing the need for aggregation and backhaul of traffic and complicating the configuration and management of the network. When this trend is combined with the advantages of migrating towards NFV and SDN-enabled networks, and the related change in traffic from centralized to distributed networks, a massive shift in network architecture is about to occur. This transformation is all about accelerating broadband adoption and sustaining data growth while achieving business agility and operational automation to keep network costs in control.

A distributed access network may have one, two or even three orders of magnitude more NEs than a centralized access network. The topology of the network may be much more varied than the predominant star arrangement of centralized networks. Ring, chain, tree and branch and even mesh topologies are possible. The network will be more heterogeneous with point-to-point and PON fibre links feeding the NEs and with fibre, copper, RF-over-coax and wireless links to subscribers.

This distribution of the physical layer termination function and the increasing availability of long-range high speed optical transmission options (PON, point-to-point or other) allows for accelerated fibre deployments to go deeper in the network and consolidate Central Offices, Hub Offices and Switching Offices that traditionally were required to be within a few kilometres of the end user. The remaining central offices are natural locations not only for traffic aggregation but also for centralizing the control of the distributed and software-defined access network.

Conclusion

The Access Network plays a key role in the delivery of services to end users. With the rapid growth of cloud-based services, the need for continuous reliable access to the network is paramount. As the part of the network closest to the end user, the Access Network is ideally located to implement SDN controlled mechanisms to optimize flows for specific applications. In addition, the Access Network is well positioned to absorb functionality of CPE devices without compromising performance or latency. Furthermore, with the increase in the dynamic instantiation of applications (through virtualization), rapid growth of small cell deployments, and end user demand (through increased usage of tablets and other Wifi-enabled devices), the need for dynamic control of the Access Network becomes critical in order to ensure that these applications and devices are automatically served by network slices with characteristics appropriate to their needs.

Chapter 7: Sharing FTTH networks

The installation of new FTTH networks may require very costly civil works for the deployment of new cabling for outside plants, MDUs, as well as inside the home. These costs may inhibit the deployment of FTTH, and, in a competitive environment, if these same costs need to be borne by each competing operator, the level of competition will be limited and in addition, result in inefficient investments. Regulators are looking at ways to encourage new FTTH deployments and to meet national targets. One remedy would be the effective sharing of infrastructure costs by multiple competing operators and may even provide non-telecom players the opportunity of participating in FTTH build outs, e.g. utilities, municipalities, and real estate developers. However, cooperation among competitors may need to be facilitated or mandated by regulatory authorities.

Sharing options at various layers

FTTH infrastructure may be shared or “unbundled” at various layers for either point-to-point (PTP) fibre or point-to-multipoint passive optical network (PON) architectures. These layers are classified in Figure 5 from the lowest layer of sharing up to the highest, as described below.

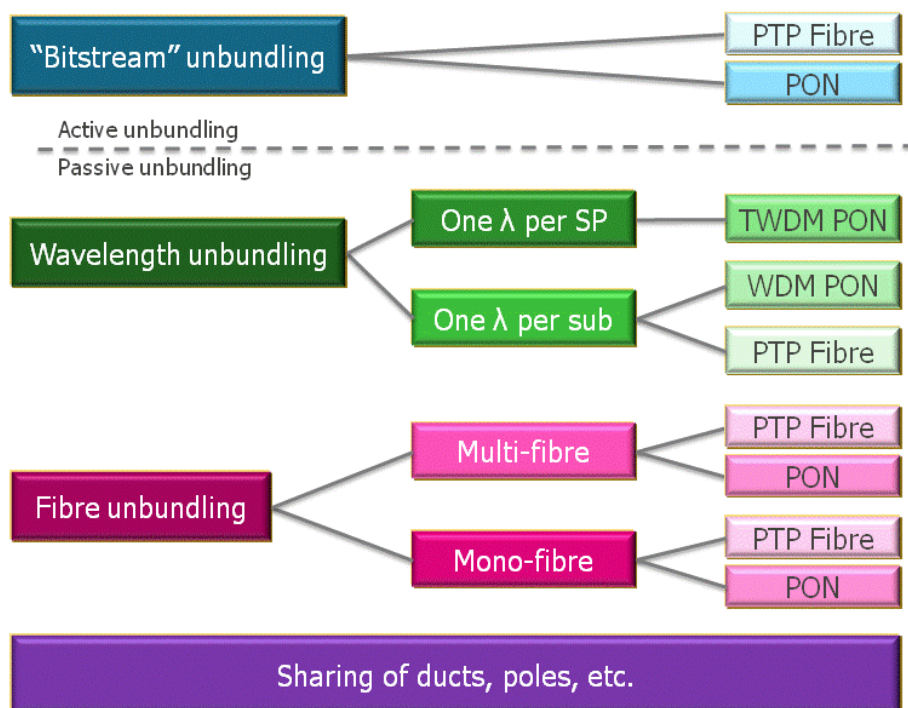


Figure 5: Classification of infrastructure sharing for PTP Fibre and PON FTTH.

1. **Active or “bitstream” unbundling** (includes VULA) – in this scenario, a wholesale operator provides transport from the subscriber’s premises back to a point of interconnect (PoI), where retail service providers can connect at L2 (Ethernet) or L3 (IP). A wholesaler operates and maintains both the active FTTH infrastructure, including the OLT and ONU, and all passive infrastructures in between. An example

is the NBNCo's GPON network in Australia. In Europe, BT Openreach operates a wholesale VDSL2 network on this principle.

Bitstream Pols can function as the network ports on a PON OLT, or can be located further back in the network on a L2 or L3 switch.

Bitstream unbundling might also be realized using SDN network virtualization or "slicing", in which a single physical network is partitioned into multiple virtual network "slices", each of which can be independently controlled by a Virtual Network Operator (VNO). In this way, multiple VNOs can share a common FTTH network. A network hypervisor would provide resource isolation between the VNOs while allowing each VNO to control their slice of the network.

In the following passive unbundling scenarios, each service provider is responsible for providing their own active equipment, i.e. their own OLT and ONU.

2. **Wavelength (λ) unbundling** – in this scenario, competing operators share the same fibre, but maintain separate connectivity by using separate transmission wavelengths, i.e. wavelength division multiplexing (WDM). Wavelength unbundling can be further divided into one wavelength per operator or per subscriber.

- a. One λ per operator. On a PON network, this could be done by wavelength stacking of individual operators' logical TDM PON signals, using TWDM PON technology. Each competing operator is assigned a single port (corresponding to a pair of unique downstream and upstream wavelengths) on a Pol, which in this case is a DWDM mux/demux, which may be either passive or have optical amplification.
- b. One λ per subscriber. Alternatively, each subscriber on the PON network could be assigned a unique wavelength pair, using WDM PON technology. Access to the individual subscribers is provided by a passive Pol DWDM mux/demux, each port corresponding to an individual subscriber. Operators will have a physical connection to the Pol for every subscriber they serve. In general, the more wavelengths the more expensive the equipment costs.

In principle, one λ per subscriber unbundling could also be done on a PTP architecture.

3. **Fibre unbundling** – in this scenario, multiple competing operators cooperate to share the cost of the deployment of new cables to provide fibre connectivity to homes, and/or to share an existing cable. Each cable contains multiple fibres, and by agreement each operator is allocated exclusive use of one or more of those fibres—a kind of space division multiplexing. Fibre unbundling can be further divided into multi-fibre and mono-fibre unbundling.

- a. Multi-fibre. There is a dedicated fibre from each competing operator's OLT to each home. For example, to support 4 competing operators, each home will be connected with 4 fibres. In a PTP architecture, the operators connect their OLTs directly to the dedicated fibres allocated to them. In the PON architecture, all the competing operators provide their own PON splitter, co-locating them in a common location (e.g. an outside cabinet, or an MDU basement). And each operator provides their own feeder fibre connecting the OLT to the splitter. As such, each operator has

their own dedicated end-to-end FTTH network, but share the civil works cost and the cable sheath. Some municipalities in Switzerland provide an example of this practice.

- b. **Mono-fibre.** There is a single fibre connection, shared by all competing operators, to every home. Connectivity to the fibre is provided at a Pol by a fibre cross-connect, typically a passive, manual connectorized fibre distribution panel. The Pol cross-connect provides access to each home to only one operator. When a subscriber changes operators, the connection to the old operator is replaced with a connection to the new operator. In the PTP architecture, competing operators' OLTs are connected to the Pol; for PON, the PON splitter ports are connected to a Pol at the splitter location. Competing operators in France, Spain and Portugal have begun using this practice.
 - c. A special case of fibre unbundling is the sharing of in-building wiring in multi-dwelling unit buildings (MDUs). Fibre unbundling is extended from outside to inside the building. In the case of PON, optical splitters may be placed in the MDU basement. The vertical and horizontal cabling from the splitter to each unit can be either multi-fibre or mono-fibre. Different operational models of sharing can apply. For example in France, the first operator canvasses competing operators to see if they want a fibre installed. The first operator then deploys a multi-fibre architecture and invoices the competing operators at cost price. In Spain, the first operator can deploy mono- or multi-fibre. Competing operators can then ask for access to that infrastructure. The first operator is required to oblige, but is free to levy a charge.
4. **Sharing of ducts, poles, etc.** – in this scenario, competing operators provide their own cables, and deployment costs of the cable are minimized as access to ducts, poles, rights-of-way etc. are made equally available to them. Examples of entities providing such access are the incumbent operator, utilities, and municipalities. However this is not an unbundling activity per se.

Comparison of unbundling strategies

1. Capex –

- Bitstream unbundling eliminates the duplication of per-operator active and passive infrastructures, and in general will therefore require the least capex.
- Of the fibre unbundling scenarios, mono-fibre requires fewer fibres than multi-fibre, and in the case of the PTP architecture, will always require less capex. The same is true for PON architectures, as long as the per-home-passed cost of the Pol cross-connect is less than the cost of the additional fibres connecting each home.
- Wavelength unbundling architectures, such as bitstream unbundling, minimize the number of fibres. On the other hand, like fibre unbundling, each operator must provide his own OLT. The major capex factor however is the relatively high cost for the DWDM mux/demux (compared to a passive cross-connect) and DWDM-compatible optics in the OLT and in the ONU. Some WDM PON or TWDM PON implementations require tuneable transmitters and/or receivers in the ONU.

Some WDM PON implementations require a DWDM wavelength multiplexer/de-multiplexer to “route” wavelengths to /from ONUs in place of the PON power splitter. For the near future at least, the capex of wavelength unbundling strategies will be problematic. Meanwhile, there are efforts underway to reduce the cost of TWDM PON optics that might enable this option in the longer term.

- **PON vs. PTP.** There is an expanse of literature on this topic. The main points to consider for unbundling capex are (1) PTP architectures require more fibres than PONs in the feeder section, and (2) large per-subscriber Pol cross-connects, analogous to copper MDFs, are required.

To summarize the capex comparison in the infrastructure-sharing scenario, PON bitstream unbundling and PON mono-fibre unbundling will generally require the least capex. PTP bitstream and PTP mono-fibre unbundling can be capex-effective for short feeder lengths (or for remote OLTs in “active Ethernet” architectures). PON multi-fibre unbundling can be capex-effective for short distribution lengths (e.g. when the splitter is placed in an MDU basement).

2. **Opex** – there are many factors contributing to opex, but probably the most important operation in the context of unbundling is the manual reconfiguration of physical connections at the Pol during churn. This operation is required for PTP architectures, WDM PON, and PON mono-fibre unbundling and has the largest impact when a truckroll is required to a remote Pol, as with PON mono-fibre and PTP architectures with remote OLTs. Bitstream, PON multi-fibre, and TWDM PON architectures do not require this operation.
3. **Flexibility** – there are a number of attributes pertaining to unbundling that fall into this category. The most important are:
 - Ability to support more than one service provider per subscriber: readily supported by bitstream and multi-fibre unbundling architectures.
 - Ability to support a large number of competing service providers: multi-fibre architectures are limited by the number of fibres deployed per home, while TWDM PON is limited by the number of wavelength pairs supported (starting at 4 but which may increase in the future).
 - Low start-up cost barrier for new entrants. In the PON multi-fibre and PON wavelength unbundling architectures, all homes passed are connected, not only paying subscribers. For new entrants, starting with low take rates, this leads to low OLT port utilization, since most homes connected to each new entrant’s PON OLT ports are taking service from other providers. This represents a higher cost per subscriber compared to more established operators with higher take rates, and may represent a higher barrier to entry. On the other hand, PTP and PON mono-fibre architectures allow for grooming of subscribers to fewer OLT ports, minimizing this effect. Bitstream architectures pose an even lower barrier, not even requiring the start-up cost of an OLT.

Regulation

Directive 2014/61/CE on broadband cost reduction is an initiative by the European Commission to establish a minimum set of conditions for infrastructure sharing across Europe. At high level the initiative has 4 main elements, or “pillars”, which deal with access to existing infrastructure, co-ordination on new infrastructures, permit and administrative thresholds and in-building wiring. A dispute settlement procedure is also included in the Directive to ensure proper administration.

Note that many Member States go beyond these minimum criteria, in particular in Portugal, Spain and France.

All EU Member States must transpose the Directive into national legislation with the provisions taking effect by 1 July 2016 (31 December for in-building wiring).

Pillar 1: Access to and transparency of existing physical infrastructure

The Directive aims to create a market for physical infrastructure such as ducts, poles, manholes without covering cables, or dark fibre. Therefore, any electronic communications or utilities operator may enter this market and offer access to its physical infrastructure.

Moreover, any network operator is obliged to provide access to its physical infrastructure for the deployment of high-speed broadband networks (30 Mbps and above), upon reasonable request and under fair terms and conditions, including price. Access may however be refused for objective, transparent and proportionate reasons. A Dispute Resolution Mechanism is in place if no commercial agreement can be found.

In order to enable access to physical infrastructure, public sector bodies and network operators must provide, on request, minimum information including a contact point. They must also consent to on-site surveys, at the cost of the access seeker. Access to information may be limited for reasons of network security, national defence, public safety or confidentiality.

Pillar 2: Coordination & transparency of planned civil works

Any network operator may negotiate coordination of civil works with electronic communications providers. In addition, civil works, fully or partially financed by public means, have to meet any reasonable request for coordination of such works, provided additional costs that may be incurred are covered by the communications provider and that the request is made within reasonable time.

In order to facilitate future coordination of civil works; proposed civil works must be made public 6 months in advance. When a party, authorised to provide public communications networks, requests information concerning planned civil works, the network operator has to make available a minimum level of information about the planned civil works. Access may be refused if information is already publicly available or via a Single Information Point. Member States may limit access to the information if this infringes on the security and integrity of the networks, national security, public health or safety, confidentiality or operating and business secrets.

Pillar 3: Permit granting

All relevant information relating to procedures surrounding the granting of permits for civil works must be available via a Single Information Point. Member States are encouraged to make it possible for permit applications to be submitted electronically. In any event, unless national law specifically provides otherwise, all permit decision should, generally, be made within 4 months.

Pillar 4: In-building infrastructure

All new buildings shall be equipped with physical infrastructure, such as mini-ducts, capable of hosting high-speed networks and with an access point that is easily accessed by the providers of public communications networks. The same applies to major renovations. Member States may make exemptions on proportionality grounds, such as for monuments or military buildings.

Providers of public communications networks have, at their own cost, the right of admittance to access points, and through them gain entrance to any existing in-building physical infrastructures. Holders of the rights to use these access points and the in-building physical infrastructure shall meet reasonable requests for access under fair and non-discriminatory terms and conditions, including price. Member States may grant exemptions from this obligation when access to an in-building network is ensured on objective, transparent, proportionate and non-discriminatory terms and conditions (open access model).

Dispute Resolution Body & Single Information Point

Member States are obliged to appoint one or more independent body/ies to resolve disputes between network operators regarding access to infrastructure, access to information and requests for coordination of civil works. Member States have the flexibility to appoint already existing body/ies, or establish new body/ies ad hoc. Moreover, Member States have to initiate one or more Single Information Points where information relating to physical infrastructures and permits are available.

Chapter 8: Regulation

Understanding laws and regulations on both a country as well as a European level is vital as business decisions made during FTTH project planning will be affected by them. Of course, regulations apply to many diverse areas of business; this Chapter will consider a topic of specific relevance to FTTH deployment: regulations that impact on the electronic communications sector.

Principles of regulation

The purpose of regulations is to address market failures that manifest themselves in a number of ways. A classic example is the monopoly telephone provider offering a limited service at an extortionately high price. In fact, until the 1980s, the telecommunications sector in Europe was dominated by State-owned operators, and prices for voice communication were high by today's standards, especially for long-distance calls.

In 1988 the European Commission began the process of liberalising the electronic communications market, using competition legislation and regulations to remove policy measures introduced by Member States that granted exclusive or special rights to operators. Major milestones were passed in July 1990 when services, other than voice telephony, were liberalised and later in January 1998, when voice telephony was also liberalised. This has allowed new operators to access the market, creating competition which has dramatically reduced the cost of long-distance telephone calls and paved the way for the proliferation of mobile phones.

In a FTTH context, a lack of high-speed broadband services in rural areas is a clear case of market failure. Another would be the inability to consider all the costs and benefits when making a business decision. The provision of improved health care services or increased teleworking have, for example, brought great benefits to society, areas where network operators normally have difficulty in substantiating in their business plans. The non-inclusion of these positive benefits is a market failure (which can be rectified by an intervention such as public financing).

There are two main mechanisms for market regulation:

- **Competition legislation** – penalising businesses for anti-competitive behaviour (referred to as ex-post regulation).
- **Sector specific regulations** – where it is judged that a company has significant market power (SMP), the market can be regulated in advance of any anti-competitive behaviour (referred to as the ex-ante approach).

The National Regulatory Authorities (NRA's) of European Member States administer ex-ante regulation and must comply with the appropriate European legislation when setting regulatory policy. The current legislative framework for regulating the electronic communications sector was adopted in September 2009 and is known as the "Telecoms package" and includes five Directives:

- Directive to establish a harmonised framework for the regulation of electronic communications networks and services (the “Framework Directive”)
- Directive on the authorisation of electronic communications networks and services (the “Authorisation Directive”)
- Directive on access to, and interconnection of, electronic communications networks and associated facilities (the “Access Directive”)
- Directive on universal service (the “Universal Service Directive”)
- Directive on the processing of personal data (the “Privacy and Electronic Communications Directive”).

The Telecoms Package was further amended in December 2009 with the addition of the “Better Regulation Directive” and the “Citizen’s Rights Directive”.

The main changes brought in by the Telecoms Package allows NRA’s a greater say on when and where regulation is needed and provides the Commission with additional influence in NRA decisions regarding their interventions. In general the 2009 Telecom Package placed greater emphasis on encouraging investment. There are also specific provisions relating to NGA deployment, which includes FTTH. The overall aim is to promote competition, while encouraging more consistent regulation across Europe.

The **Body of European Regulators for Electronic Communications (BEREC)**, comprises of the Heads of 27 NRA’s and was established as a result of the 2009 Telecoms Package. BEREC’s function is to advise the Commission and develop and disseminate regulatory best practice, such as common approaches, methodologies or guidelines on the implementation of the EU regulatory framework. Next-generation access (NGA) forms one of BEREC’s more active work group areas.

The Commission has defined four product and service markets within the electronic communications sector where ex-ante regulation may be warranted (see Recommendation C(2014) 7174 final for product market descriptions). Two markets which are directly relevant to FTTH networks are::

- 3 (a) Wholesale local access provided at a fixed location
- 3 (b) Wholesale central access provided at a fixed location for mass-market products

NRA's must follow a three-step process for regulating these markets:

Step 1: Market Definition	Step 2: Market Analysis	Step 3: Market Remedies
Market 3(a) Wholesale local access provided at a fixed location	Market 3(a) Always dominated by the former incumbent operator in a copper context. Cable is excluded from the market. In a FTTH context, different results are possible, e.g. no-SMP finding in Romania based on multiple FTTB networks.	Market 3(a) Grant access to the physical path of the network. If not technically nor economically feasible other remedies are permitted including access to VULA as an alternative.
Market 3(b) Wholesale central access provided at a fixed location for mass-market products	Market 3(b) Can still be competitive even if SMP on market 3(a) (dependent on product definition and geography).	Market 3(b) A range of possible remedies including different levels of bitstream access, different pricing mechanisms, etc.

NRA's look at the entire value chain from the passive infrastructure to the retail services. It is obvious that the choice of where and how to award access in the value chain will impact on operators' opportunities to enter the market and determine the nature and range of services delivered to retail consumers. In extremis, even if wholesale products are available but limited, if any, alternative operators enter the market to supply at the retail level, NRA's may regulate the retail product directly via price caps in an effort to protect end-users. An overwhelming preference is to allow as many operators as are interested by making appropriate wholesale products available and allowing competitive processes to work as freely as possible.

Where dominance exists NRA's must propose at least one remedy which should be introduced as high as possible in the value chain (further from the end-user) as wholesale regulation leaves more room for competitive entry into the market. Retail regulation is viewed as a last resort.

Proposed remedies:

- **price control**, including cost orientation – limiting wholesale pricing to the cost of maintaining the access network
- **transparency** – the basis of wholesale pricing must be made public
- accounting separation
- **non-discrimination** – wholesale prices not dependent on purchase volume
- mandatory access to specific facilities – typically access to the central office
- mandatory provision of specific facilities – e.g. power in the central office.
- **functional separation** whereby the network and service divisions are operated independently of each other.

Under the Framework Directive a series of symmetric remedies are also available which are applicable to all operators in the electronic communications market, regardless of size. While many of these remedies relate

to consumer contracts and consumer rights, some important obligations regarding infrastructure sharing also exist under this heading. However, over time the infrastructure provisions in the Framework Directive proved ineffective and so the Commission proposed a new Directive, Directive 2014/61/CE on broadband cost reduction is an initiative by the European Commission to establish a minimum set of conditions for infrastructure sharing across Europe. At high level the initiative has 4 main elements, or “pillars”, which deal with access to existing infrastructure, co-ordination on new infrastructures, permit and administrative thresholds and in-building wiring. A dispute settlement procedure is also included in the Directive to ensure proper administration. This topic is dealt with at length in Chapter 5.

The Digital Agenda Targets

In March 2010 the European Commission launched the “Europe 2020” strategy to prepare the EU economy for the next decade.

The Commission has identified the need to increase European access to high-speed internet connections. The Digital Agenda restates the objective endorsed by the European Council to bring basic broadband to all Europeans by 2013 and adds a more ambitious target for 2020: 30 Mbps available to all households with a 50% subscription rate to offers of 100 Mbps minimum.

The Commission is reviewing these broadband targets with the aim of introducing new targets during 2016. While these targets are aspirational, they do provide an objective for those public authorities that are in the process of building networks. Just as important, these targets also provide a network performance goal which NRA's can strive to attain.

NGA Recommendation

In September 2010, the European Commission published a **Recommendation on regulated access to NGA networks** that seeks to guide NRA's as to the appropriate market remedies for NGA Networks. This is a non-binding text based on Article 19 of the Better Regulation Directive; however, NRA's must “take utmost account” of these guidelines when selecting remedies as part of their analysis of Markets 4 and 5.

It is clear in the Recommendation that preservation of competition is paramount and that access in the form of fibre unbundling and/or active access will continue as in the past. Such access conditions will include risk premiums to attract investment.

The Recommendation gives priority to remedies aimed at reducing deployment costs, such as granting access to passive infrastructures. Specifically on this point, the Recommendation suggests a combination of Article 12 of Directive 2002/21/EC (Framework Directive) and Article 5 of Directive 2002/19/EC (Access Directive) as a legal basis to justify mandating access to passive infrastructures.

There are further provisions which require NRA's to work with other authorities to establish a database containing information on geographical location, available capacity and other physical characteristics of all civil engineering infrastructures which could be used for the deployment of optical fibre networks in a given market or market segment. The resulting data-base should be accessible to all operators.

NRA's are also guided to mandate access to the terminating segment of the access network to any operator with SMP. This includes access to wiring inside buildings. In this context NRA's are obliged to provide the SMP operator with detailed information relating to its access network architecture and, following consultation with potential access seekers on viable access points, determine where the distribution point of the terminating segment of the access network should be located for the purpose of mandating access.

The Recommendation further advises that NRA's should take into account the fact that distribution points will need to host a sufficient number of end-user connections to be commercially viable for the access seeker. NRA's are also asked, where possible under national legislation, to oblige the operator with SMP to deploy multiple fibre lines in the terminating segment.

Where the SMP operator deploys FTTH, NRA's should in principle also impose fibre unbundling, regardless of the network architecture, with an access point at the metropolitan point of presence. The Commission suggests that technological development will address unbundling difficulties in time (e.g. through wavelength unbundling) and that in the meantime alternative options such as "virtual unbundling" (e.g. VULA as in the UK) could be offered as a substitute for a transitional period. However, NRA's are recommended to "mandate physical unbundling as soon as technically and commercially feasible".

NRA's are required to ensure that there is sufficient information on network plans available to the market to facilitate the transition from copper- to fibre-based networks. In practice these plans are an important factor for an NRA in its role as a co-ordinator of co-investment schemes.

The Recommendation points to specific circumstances where regulation may not be necessary. NRA's have the option of defining sub-national markets if substantially different competitive conditions, which are stable over time, can be identified; or they can define broader geographic markets but limit the geographic scope of remedies applied. NRA's can waive the requirement for unbundled access in geographic areas where there are several alternative infrastructures, such as FTTH networks and/or cable, in combination with access offers.

There is also the option of removing regulation completely if operators co-invest on the basis of multi-fibre lines and the conditions attached to the co-investment project assure equality of access for all participants. In practice the various opt-outs from regulation suggests that, under certain circumstances, there may be no SMP finding.

Even if a finding of SMP is made, investors may, under certain circumstances, also enjoy greater discretion when setting access prices, for instance with co-investment schemes which seek to foster market-driven investment outside densely populated areas. Where physical access remedies are working well in a market, greater pricing discretion in relation to bitstream access can also be allowed.

This guidance, if fully implemented, could have a significant impact on deployment models. Even with the guidance in the NGA Recommendation, NRA's enjoy considerable discretion concerning the details of the remedies to be applied at national level. Readers are advised to consult with their local NRA's to ensure appropriate knowledge of local policies.

The Treatment of State Aid

Any economic entity which receives government support gains an advantage over its competitors. Therefore, the Treaty generally prohibits state aid unless it is justified by reasons of general economic development. To ensure that this prohibition is respected and exemptions are applied equally across the European Union, the European Commission is charged with ensuring that state aid complies with EU rules.

The European Commission adopted revised guidelines for the application of EU state aid rules to the broadband sector in 2013. These changes focus on the following principles and priorities:

- **Technological neutrality:** the new guidelines take into account technological advances, acknowledging that super-fast (Next Generation Access) networks can be based on different technological platforms.
- **Ultra-fast broadband networks:** to help achieve the Digital Agenda objective of delivering very fast connections (of more than 100 Mbps) to half of European households by 2020, the revised guidelines will allow public funding also in urban areas but subject to very strict conditions to ensure a pro-competitive outcome.
- **Step change to connectivity:** to protect private investors, the guidelines require that any public investment must fulfil a so-called "step change": publicly financed infrastructure can only be allowed if it provides a substantial improvement over existing networks and not solely a marginal improvement in citizens' connectivity.
- **Reinforcement of open access:** when a network is realised with taxpayers' money, it is fair that the consumers benefit from a truly open network where competition is ensured.
- **Transparency:** new provisions regarding the publication of documents, a centralised data base for existing infrastructure and ex post reporting obligations to the Commission have been introduced.

Applications to the Commission for state aid clearance must go through the national contact point - there may even be an approved scheme operating in your country so that state aid can be approved without recourse to Brussels. Any questions can be put to the State Aid Unit of DG Competition stateaidgreffe@ec.europa.eu.

The Commission's objective is to ensure competition is not distorted via state aid; seeking to encourage investments with no interest in impeding such investments. To date, hundreds of applications have been submitted and only once has a state aid proposal in the broadband domain been refused.

Recommendation on consistent non-discrimination obligations and costing methodologies

The European Commission brought forward a further Recommendation in 2013, entitled 'Recommendation on consistent non-discrimination obligations and costing methodologies' to clarify and fine tune certain aspects of the NGA Recommendation. This Recommendation provides guidance on the appropriate methodology for pricing copper loops and specifies the conditions under which SMP operators of NGA

infrastructure can enjoy greater pricing freedom (for example, the presence of anchor products). It is recommended that you talk to your local NRA to understand the parameters of the regulatory regime and how they are applied in your country.

A list of NRA's is contained in Appendix B.

Chapter 9: Finance FTTH

Introduction

Almost four years have passed since the FTTH Council Europe published its 4th edition of the Business Guide. Many governments, institutions and consultancies have also issued similar guides and handbooks. During this period we have organised nine Investor workshops across Europe, which have also contributed, to our learning curve. As a result of our activities and continual exchange with industry stakeholders, we can now conclude that the clear advantages of a sustainable fibre access infrastructure have finally gained acceptance in the marketplace. We are under the impression that the investment case is now far better understood and yet, it still remains extremely challenging to make the case for FTTH in non-urban markets. Sadly though, in some European markets, problems still occur in urban markets when the incumbent follows a strategy of copper enhancement. In such situations, we think those cable operators that already have a presence in the market, could possibly transform into FTTB operators over time.

1. From push to pull – a fresh look at financing FTTH

Thus, we decided to discuss how to finance the next level of FTTH and concentrate on non-urban markets. We shifted focus towards more equity versus debt instruments and addressed the following aspects in more depth:

- Project size as a critical factor in attracting investors
- Incentives that are built in financing structures
- Associated with the above, the role of options or trigger events that can lead to changes in the capital structure, i.e. ownership.
- Other developments on the European level such as the EFSI ('Juncker Plan') or regional level (community share programmes, for example)

We will also introduce an insightful approach into looking at investment cases: options. In a number of situations, so called 'real options' correspond very well to our instinctive choices and form part of many business decisions, although these are sometimes hidden. We will abstain from complicated maths and concentrate on the concept; including case studies. We think, in some cases, the reader will have an a-ha experience. This should appeal to project owners, investors and policymakers alike.

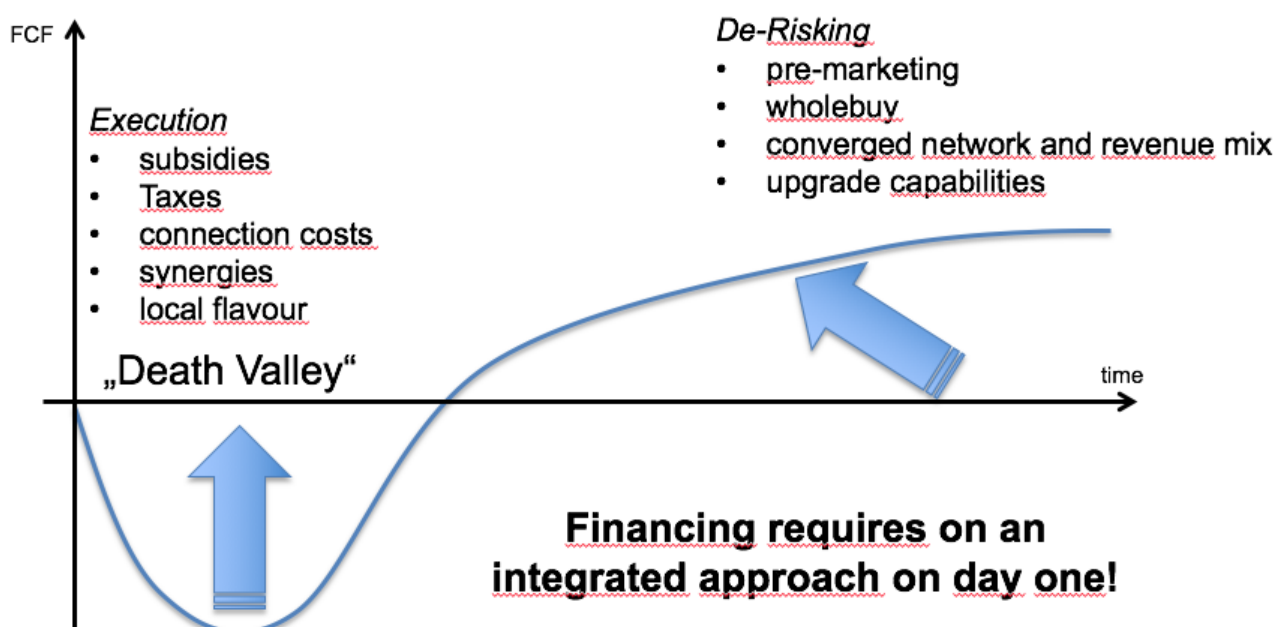
2. The 'standard' problem of the past and the desired 'fix'

Although the following might be an over-simplification we think that this approach has been quite common for smaller projects: A project sponsor (a new company, a utility or municipality for example) has decided to roll-out an FTTH network and is keen to offer triple or even quadruple play services, based on white label solutions from the open market. As infrastructure projects are capital intensive, they face the so-called Death Valley problem: significant negative available funding due to heavy investments in the early project phase and often coupled with very low operating cash flow in the subsequent first years. This problem can be

mitigated but not fully offset by presale activities. The business model usually shows good growth in subscribers and revenue with an achievable break-even point sometime during year 5 to 15 after project start.

The financing problem from the viewpoint of the sponsor is as follows: The sponsor needs an inexpensive bank loan with long tenure requiring no capital payments in the first few years. But from the banks' point of view, the subscriber growth expectations or pricing trends are excessively optimistic, construction risks are not very well managed and there is the prospect that a competitor may build a similar access infrastructure. The bank has no experience with broadband projects, cannot quantify the risk and does not accept the network as collateral. In addition, the Basle III financial regulation does not make long-term lending by the banks a very attractive option.

Chart Death Valley and mitigating measures



Source: FTTH Council Europe

The next round of discussions centre on whether development banks should step in. This proposal is supported in a study conducted by the European Commission: „it is felt that the greatest impact comes from investing in early stage broadband infrastructure projects. These are also the type of high risk but modest upside ventures that are ill-served by equity investors. Without cash flow they are not bankable. So, having conducted a number of interviews, from a diverse range of sources, a clear message emerged: **the overall best approach for the €180m CEF is to support new broadband projects that can scale later and to do**

so by making long tenor loans on appropriate terms consistent with EU policy goals.² We should like to point out that this might solve the funding problem today but does not reduce any operational or market risks, per se, tomorrow. This quote also points to a key issue that we will address below. Namely, how can additional equity investors be enticed to bankroll access infrastructure? How can one mitigate risks and/or increase the upside?

The funding problem is different for those companies operating several businesses. They can benefit from cash flow between operations and use the balance sheet to finance projects. The problem, therefore, is not limited to availability of funds but gaining approval from shareholders. Likewise, in the public sector, wealthy municipalities or communities can invest in fibre safe in the conviction that it will eventually pay off – either financially, socially or both. But very few communities can be called ‘rich’ as pressure mounts on them to maintain a wide variety of public infrastructures at a time when they may already be highly in debt. Problems may be of a different kind: incumbents may be enjoying a healthy profit margin on a largely written-off copper infrastructure and see no financial incentive to turn their attention to fibre. These situations have thus given rise to the discussion of co-investment models of private partners, PPP models and state aid. It has become very clear that rolling out fibre is as much a financial challenge as a strategy issue.

3. Introducing the Options Framework

In the preceding section we were on a tour de force of financing dilemma, now we want to turn our attention to solutions. Introducing optional frameworks will prove insightful by improving the process of finding suitable funding. It might be of interest to the reader to know that in 2005 the UK regulator Ofcom „... propose[d] to analyse the case for the application of real options to individual wholesale products on a case -by-case basis“³. What is an option? In short, it is the right to choose. It may be useful to distinguish between three types of options:

- Financial options
- ‘Contractual’ options
- Managerial, i.e. real options

Financial options

Financial options are securities that can be traded on stock exchanges. They can be used to hedge various financial risks and can just as equally be used to make highly speculative investments. A simple example shall suffice. Let’s assume you purchase an option entitling you to buy one IBM share valued at \$100 for a price of \$5 over the next 3 months. The current share price is \$90. In scenario one, the price of the IBM

² See European Commission (Publ.) (2014) Assessment of the alternatives for, market sentiment towards, and recommendation of the most effective financial instrument(s) for the CEF broadband activity, p. 3

³ See Ofcom (Publ.) (2005) Ofcom’s approach to risk in the assessment of the cost of capital. Final Statement. Office of Communications, p. 101. Although Ofcom has, to our knowledge, never applied real options analysis in practice, it remains open for a discussion about its applicability.

share increases to \$110. You have the right but not the obligation to exercise the option but it clearly makes sense to buy the share for \$100 and sell it on the market for \$110. So with an investment of a mere \$5 you made a return of $\$110 - \$100 = \$10$ – a 100% return!

However, in scenario two the share price only increases to \$95, therefore it is better not to exercise the option of buying and risk losing all your \$5 initial investment.

Financial options can be combined with other financial securities. A convertible, for instance, is a bond with options attached to it allowing the bond to be exchanged for shares. The result is lower leverage and a higher equity ratio.

This is all we will say about financial options. The example, nevertheless, illustrates two important points: options always have positive value (which is intuitively clear), the higher the risk, the higher the value (which is perhaps less obvious). The latter can be explained as follows: options love volatility which is another word for the fluctuation in the underlying (in our example the price of the IBM share). All that is required is that fluctuations are large enough to exceed the so-called exercise price (\$100 in our example). We will get back to these points later.

‘Contractual’ options

Contractual options cover rights in financing arrangements which, if exercised, will lead to changes to the capital and/or ownership structure. Term sheets or shareholder agreements between companies and Private Equity firms (PE) often contain so-called pre-emption rights or rights of first refusal which gives the PE the option to buy additional shareholdings before other parties are asked for offers. Tag-along rights give the investor the right to sell their stake based on the same conditions as offered to the majority shareholder. Companies should minutely scrutinise such arrangements. Hilpisch⁴ provides an interesting case study in which he concludes that „... In the case study the value added by the term sheet is over 50% relative to the initial investment. The reduction in risk is up to 15%-points. These effects are so large that no one can really argue that they can be neglected. Therefore the analyses in this book are not only of scientific or theoretical interest, they have far-reaching consequences for the whole practice of PE and VC investments and the general M&A arena.“⁵

⁴ Hilpisch, Yves (2007) Valuation of Financial Contracts (v1.0)

⁵ *ibid.*, p. 77

A pronounced example is the Reggefiber-kpn agreement⁶. The following table summarises the option structure:

	Ownership stake	Option trigger	Exercise price	Conditions for exercise
Option 1	Additional 10% Leading to 51% ownership	Call/put vest earliest of: 1.0m Homes Connected 31 December 2012	EUR 99m	
Option 2	Additional 9% Leading to 60% ownership	Call/put vest earliest of: 1.5m Homes Connected 1 January 2014	EUR 116m – 161m, depending on Capex efficiency at Reggefiber	i) Exercise of option 1 required ii) Nma approval required

Source: Reggefiber joint-venture paper

We highlight the incentives that were built into this option scheme: Reggefiber is incentivised to increase the number of homes connected, in addition this should be achieved in such a cost efficient way as to have a positive effect on the exercise price.

Real options

Real options represent (dis-)investment opportunities in the real economy. Management can, over time, become acquainted with a new technology or react to changes in underlying market situations, such as commodity prices or the demand for broadband services. Thus, changes in market conditions can make real options attractive to identify. One such goldmine is the typical textbook example: If the market price for gold rises and passes a critical level (the exercise price) it makes sense for the mining company to invest in capacity.

There are many different types of real options. The table below shows a selection and gives some general examples from the telecommunications industry.

⁶ kpn Investor Relations (2011) Reggefiber joint-venture paper

Category	Description	Important in	Telecom examples
Option to defer	Management holds a lease on (or an option to buy) valuable land or resources. It can wait x-years to see if output prices justify constructing a building or a plant or developing a field	All natural-resource-extraction industries; real estate development; farming; paper products	Trial project, testing of LTE, market studies
Time-to-build option	Staging investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavourable. Each stage can be viewed as an option on the value of subsequent stages and valued as a compound option	All R&D-intensive industries, especially pharmaceuticals; long-development capital-intensive projects [...]	Phased network roll-out, acquiring licenses
Option to abandon	If markets conditions decline severely, management can abandon current operations permanently and realize the resale value of capital equipment and other assets on second-hand markets	Capital-intensive industries (e.g. airline, railroads [...])	Withdrawal from ISDN or Fax service market
Growth options	An early investment (e.g. R&D, lease on undeveloped land or oil reserves, strategic acquisition, information network) is a prerequisite or a link in a chain of interrelated projects, opening up future growth opportunities [...]	All infrastructure-based or strategic industries [...]	Triple play, Bitstream access

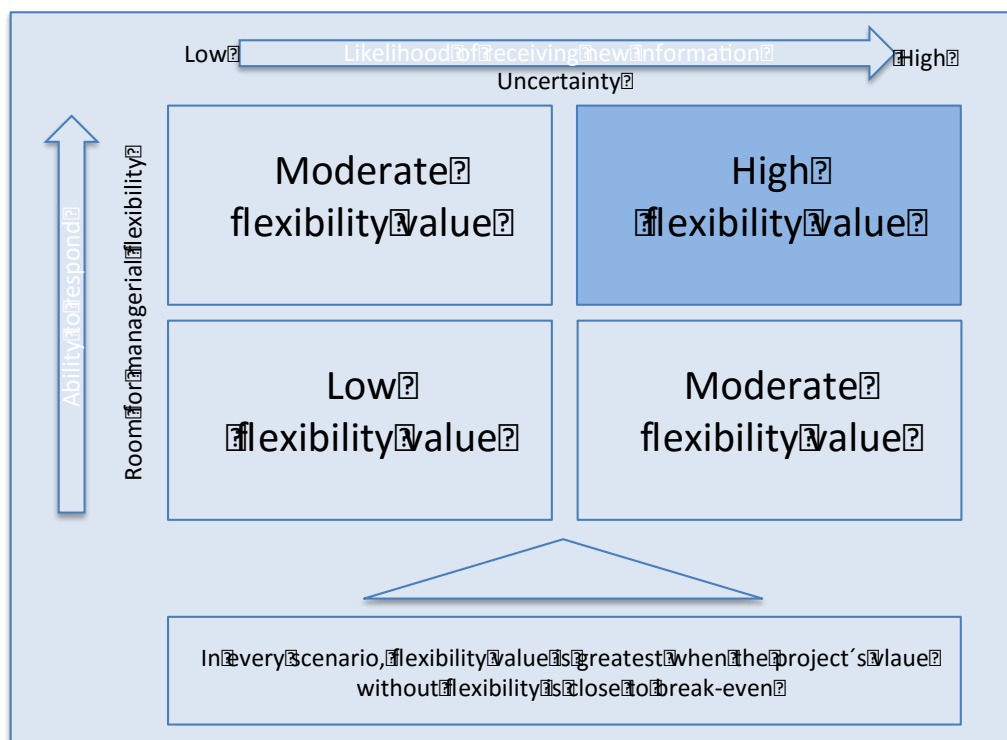
Source: adapted from Trigerious, pp. 2-3 and Tahon et. al., p. 1160

Many of these options have directly relevance for FTTH projects. The following examples show how the options approach is, implicitly or explicitly, applied to real life business decisions:

- One approach aimed at limiting the market risk is to reach a hurdle rate of service subscriptions before the actual digging starts. This is a model adopted by Deutsche Glasfaser, for example, and represents a *growth option* as the company invests in some basic local operations and marketing. The hurdle rate represents the underlying in option terminology.
- The introduction of Vectoring coupled with regulations that offer exclusivity to the active equipment operator (as is the case in Germany, the UK and Belgium (tbc!) but not in Italy) can be seen as providing an *option to defer* further investments in G.fast or FTTH technologies. Underlying in this case can be demand, the propensity to spend, or a 'positive' regulation of fibre access etc.
- Cable operators own a similar *option to defer* in their service areas: their investment policy is usually demand-led (with demand being the underlying) and they can steer capex into node splitting or amplifiers when actual or expected traffic exceeds critical levels.
- In general, project sponsors can stop a project during implementation or operation if the project faces ongoing losses. The *option to abandon* can help to limit the downside risk of a project. The case of the South Yorkshire 'Digital Region' project from 2006 illustrates that things can get worse⁷ if the *option to abandon* is not exercised! This example also sadly illustrates what can happen if you plan your network poorly: as the network could not be sold it was dismantled.

⁷ <http://www.telegraph.co.uk/technology/internet/10205444/South-Yorkshire-broadband-fiasco-could-cost-taxpayers-another-45m.html>

Chart: Introducing managerial flexibility



Source: Copeland/Koller/Murrin (2000) Valuation

4. Seven option rules to be remembered

This may seem like a mere re-presentation of some well documented cases, but does clarify what the tangible advantages are of the option approach. **First, options can be valued.** At our FTTH Conference 2008 in Munich, a simple case study⁸ showed how the consideration of expansion options more clearly helped to identify the intrinsic value of a roll-out project. Similarly, in a research paper by Sadowski, the author presented an FTTH case study and came to the following conclusion:

„ [...] The question is therefore not only if government investment is justified but under what kind of conditions will the NPV of such investment project be positive. For highly volatile and high uncertainty of demand, traditional NPV calculations accounting for these dynamics showed that there might be negative outcomes. Using a real options analysis based on its assumptions of managerial flexibility and the option to wait, the outcome were in general positive and a negative outcome could be avoided. However, the flexibility build

⁸ Pohler, Dr. «How to use the Real Options Approach in Practice to Finance FTTH-Networks »

into the investment project comes at a price of a higher (in our case 5%) initial investment in the design of the basic FTTH network.”⁹

Second, **real options can be poorly valued**¹⁰. Using real options implies making bold assumptions about the future and the variability one deems reasonable for uncertain outcomes. In this regard, it is not necessarily easier to apply than of the more traditional DCF (NPV), EVA or IRR analysis. Unfortunately, the real options approach is most enlightening when it seems most difficult to apply.

Third, as options in general and real options in particular always have a value of zero or greater, **traditional discounting valuation techniques structurally tend to undervalue projects**. Even worse, this could lead to rejecting attractive projects. The reason for this is that managerial flexibility is not reflected in a static IRR or NPV approach.

Fourth, this will likely play a role in price negotiations with Venture or Private Equity firms. We think it is not entirely impossible that a company target is expected to present a solid (conservative) DCF analysis while the purchaser internally applies option valuation. **You might strike a deal with an equity investor at a discount!**

Fifth, **real options can be abused**. The former point does not imply that every valuation from a traditional discount model is enhanced by an option component: if the base static model is flawed by wishful thinking then adding options will only make the results worse. Stellar valuations would be the result.

Sixth, a real options approach leads to the counter-intuitive result that **risk has a positive impact on valuation**. This seems to contradict the notion that future-proof networks are highly regarded by infrastructure investors for their predictable cash flows. How can we solve this conundrum? The answer is that different investors have different objectives. Later stage investors are more interested in predictable cash flows and returns to investors via interest or dividends than in value maximisation by developing the assets. Conversely, early stage equity investors are prone to taking risks and are more interested in the so-called ‘upside’ of the business. (As we stated in the beginning of this section, we will look more into early stage financing solutions later)

Seventh and last but not least, **a few investors simply disregard some real options**. It is not uncommon that infrastructure projects in the public sector are miscalculated or poorly managed¹¹. Cost overruns are then the unavoidable consequence. However, there are hardly (if at all) any projects which had to be stopped - or in option terminology – the option to abandon had to be exercised. One could argue that this is

⁹ Sadowski, Pert M. (2007) New Perspectives of Real Options Theory for Policy Analysis, University of Technology Eindhoven

¹⁰ In all fairness, we point to an interesting paper by Borison which critically evaluates different real options approaches: Borison, Adam (2013) Real Options Analysis: Where are the Emperor’s Clothes?, presented at Real Options Conference, Washington, DC July 2003 <http://www.realoptions.org/abstracts/abstracts03.html>

¹¹ see, for example, <http://flyvbjerg.plan.aau.dk/excerpt.php>

persistence...or lack of controlling and financial misconduct. However, we would argue that in cases where political logic prevents a project from being stopped, extreme attention should be paid to the planning process, financial modelling and monitoring/controlling in the very early stages in the process.

5. Public policy and real options

It appears advisable that policy makers develop a better understanding of how private investors evaluate infrastructure projects. The natural existence and, as we will see, artificial design of real options in any industry can have important ramifications for public policy. This is especially true for capital intensive industries such as telecoms and where policy changes, including deregulation, can have significant implications for market uncertainty and the potential for sunk investments. Policy-induced „Options to wait“ and „Options to expand“ can determine the timing and volume of actual investments in a specific sector:

Historically, regulation of ULL and bitstream has been one prominent example. The argument¹² that Total Service Long Run Incremental Costs (TLRICS), for example, is the wrong metric to correctly compensate the network building company for risks: The company takes on all the market and technology risk while a competitor can have regulated access to the network and terminate the contract on a monthly basis with no capital commitments incurred. In other words, the competitor has an option to wait and see if the new infrastructure leads to market demand. This is seen as an „unfair“ advantage which the building company does not have.

However, it could be argued that this „unfair“ outcome cannot automatically justify higher regulated access price to stimulate investments. The situation is much more complex and the root of all regulatory complexity is the fact that access regulation was based on a given infrastructure. In a European context, the example above relates to a greenfield investment and does not correspond to the situation of a European incumbent which might run a copper and FTTB/H network simultaneously. The EC, however, picked up on the „sunk cost“ problem (i.e. the network company invests unrecoverable amounts in an essential facility) and allowed for a higher weighted average cost of capital (WACC)¹³ in the access price regulation. Potentially this is adequate to raise profitability of the network used by early adopters but it still allows for a wholesale price gap that favours copper and prevents faster NGA penetration.

From a purely financial perspective, the problems facing policymakers looks very different. **The first question** one could ask is: does the industry (as is) generate sufficient adjusted operating cash flow (i.e. after subtracting dividends) to fund a network upgrade. Negative net investments over a prolonged time signal asset quality decreases with assets being ‘squeezed’. Possible reasons are deteriorating sector

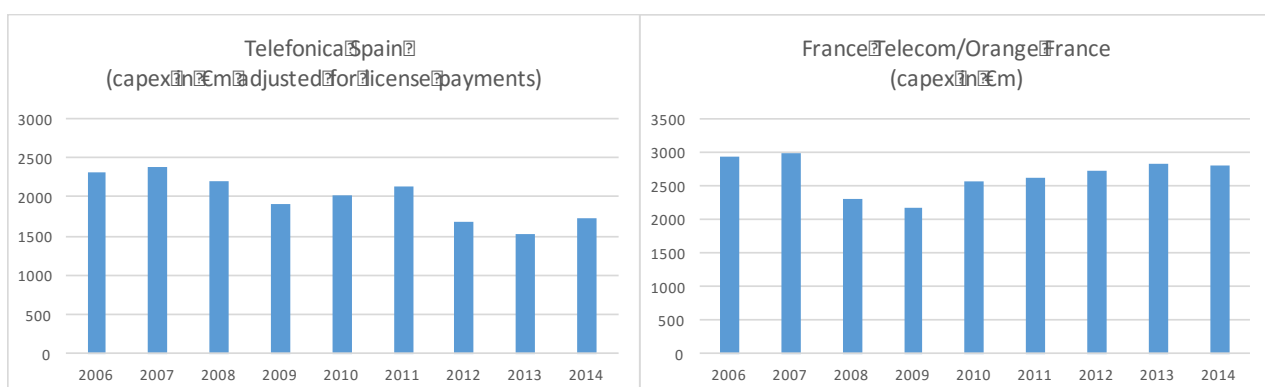
¹² Hausman (1998), The Effect of Sunk Costs in Telecommunication Regulation

¹³ European Commission (2010), Commission recommendation of 20 September 2010 on regulated access to NGA networks, Official Journal of the European Union, L 251, pp. 35-48

profitability (due to price erosion, intense competition) or an unsustainable dividend policy. Policy measures could result in a more benign regulation or encourage consolidation leading to less competition and higher prices for end-users. The flip side is that there is no guarantee that investment levels will increase. Investment levels will only increase if incremental capex supports performance metrics laid down in management incentive schemes. Clearly, it would be challenging to argue that regulation could support the defence of pay-outs to shareholders (this includes governments) at the expense of a deteriorating infrastructure.

Two observations are in order: first, detailed financial metrics about the profitability return on assets of access networks are generally not made available. This even holds true for functionally separated entities. Second, capex budgets of larger operators have a tendency to remain fairly stable. This is usually referred to as the *capex envelope*. Spikes or larger troughs are rare and if they occur are usually related to special single events such as spectrum auctions or economic crisis (such as in 2008/09). So, it might be a more promising approach to encourage a shift in capex (**in option terminology: to make a switching option attractive**) rather than to support operators' p&l.

Chart: Long-term trend in capex spending



Source: Company reports

In principle, policymakers can introduce regulatory holidays (such as in Spain for internet access with more than 30Mbit/s download speeds). This being said, regulatory holidays are not a sufficient condition to trigger NGA investments: the trend was sluggish in Spain until the years 2012/13; likewise, the initial VDSL roll-out by DT in Germany and disappointment market success. We should stress that Telefonica Spain managed to grow the number of FTTH homes passed from less than 20% at year-end 2012 to 80% by 2014. Obviously, there needs to be another element to make NGA investments attractive for operators and investors: strong and growing consumer demand which operators want to capture with bundle offers: voice, data (both fixed

and mobile) and increasingly, premium TV content. However, this creates new challenges for regulation, according to Ofcom¹⁴.

Overall, we think it is fair to say demand risk has diminished; it could also be argued that internet connectivity has become a utility. This would then imply revisiting paradigms such as „infrastructure competition“ and the „ladder of investment“ in market segments that are natural monopolies. Therefore, it is by no means clear that all investments are sunk cost; especially the passive network that could be sold in a secondary market. This leads to another policy recommendation: Enable the development of a functioning secondary market for telecom infrastructure. This could be achieved by enforcing proper documentation and minimum quality standards, supporting the due diligence process, reducing information asymmetry and eventually lead to a possible, broader acceptance of network infrastructure as collateral. **Or in option terminology: the value of the exit option would increase and investments in the primary market could become more attractive.**

The second question we should be asking is whether the telecommunications industry needs subsidised capital in order to stimulate further private investments in communications infrastructure, e.g. as proposed by the EFSI initiative. The current low-interest rate environment has become very challenging for long-term investors such as insurance companies and pension funds. Capital is there in abundance looking for investment opportunities that match the long-term investors' minimum requirements. Hence, the situation is not characterised by a lack of capital (and more investments might not even be needed as the Telefonica Spain example shows). Thus, the reason for underinvestment, or to be precise: the underinvestment in NGA infrastructure, is not related to capital; there must be other explanations:

1. Counterproductive financial market regulations could be one reason as rules for insurance companies (laid down in the Solvency II framework) and banks (Basle III) hinder long-term investments. While this is generally true; in regard to all infrastructure segments it is 100%. On the positive side, the regulating body, EIOPA, recently relaxed capital requirements for investments in infrastructure: „Qualifying infrastructure investments' will form a distinct asset category under Solvency II and benefit from an appropriate risk calibration, lower than that which would otherwise apply (for example the calibration of the stress factor for such an investment in equity is lowered from 49% to 30%“¹⁵.
2. Ignorance of financial intermediaries and investors with regard to the telco infrastructure sector could be another factor. However, the prevailing hunger for yield does not ignore the telco sector as the KKR's investment in Deutsche Glasfaser, for instance, or the successful floatation of Telecom Italia's mobile tower business Inwit shows. But it is clear that quality and quantity of the deal pipeline must justify internal investment in project teams by long-term investors. As an alternative or complement, Knowledge Hubs should be implemented that can spread costs associated with project appraisal over more projects. In principle, the European Investment Advisory Hub (for more details,

¹⁴ http://media.ofcom.org.uk/files/2015/AB_Transcript_290715.pdf, p. 5

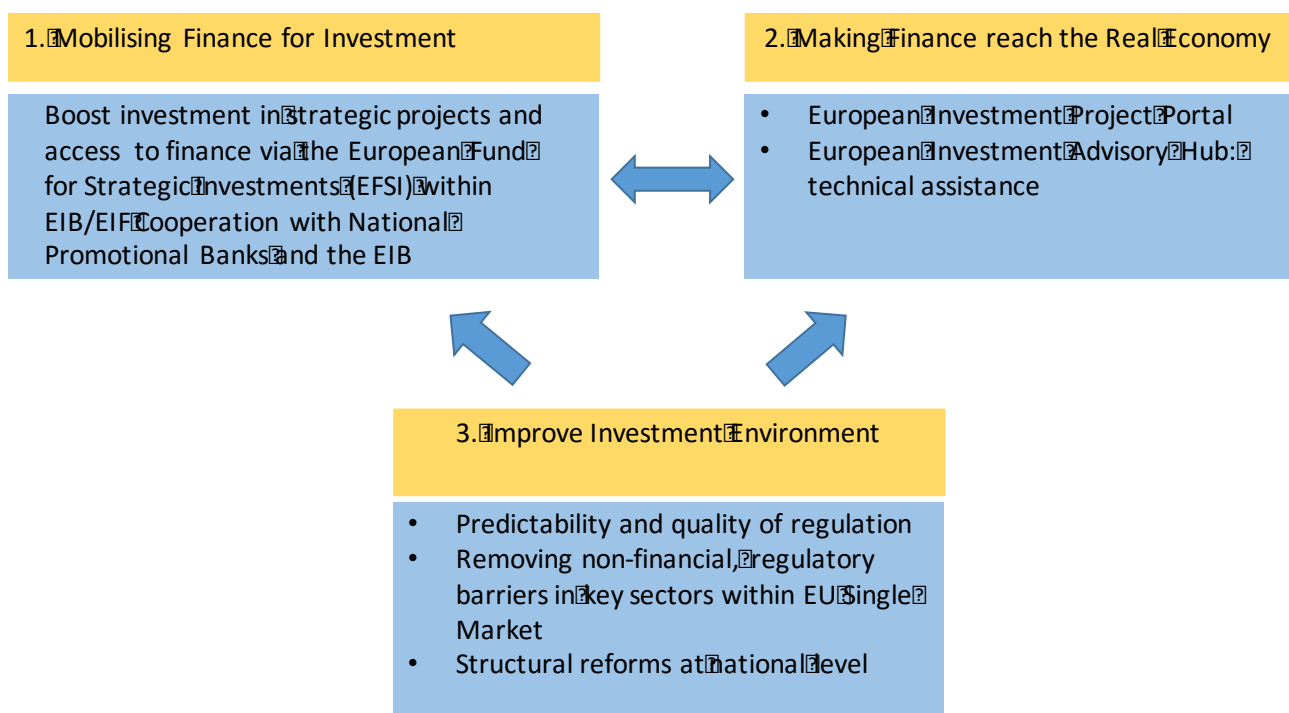
¹⁵ http://europa.eu/rapid/press-release_MEMO-15-5734_en.htm

we refer to <http://www.eib.org/eiah/index.htm>) should be a welcome initiative. And even more so if its advice is backed up by the EIB's own investments. „Put your money where your mouth is!“ would certainly increase the credibility of the approach.

3. All in all, we surmise that the main reason is the lack of project supply rather than the two factors mentioned above. This conclusion has a number of important implications.
 - a. Attempting to solve the problem with even more and subsidised capital could lead to windfall profits for companies that already have access to capital markets.
 - b. Secondly, and more importantly, it is necessary to identify and analyse the reasons for the lack of projects on the market.

In fact, the EU investment plan (see below) has three pillars and it is our opinion it would be worthwhile concentrating on pillar 3 and highlighting the need for structural reforms (e.g. eliminating government share ownership in incumbents) at national level. This alone would help to mobilise private capital.

Chart: EU Investment Plan: 3 pillars



Source: adapted from EC presentation

Based on our discussions with many stakeholders we give the following possible, non-mutually exclusive explanations and recommendations:

Case 1: The project itself is financially poor. The risk-return profile does not match minimum requirements of institutional investors. This is the so-called market failure in white areas.

Conclusion: More state aid is necessary and as budgets are, by and large, tight across Europe it is necessary to identify the most effective way to invest in sustainable infrastructure. The first measure could be to „heal“ the unattractive risk-return profile by combining a number of smaller poor projects, as scale economies might at least improve financial metrics. As we will see below size is a critical parameter. Next, gap funding could take two forms: it could either be a direct subsidy to the best bidder (traditional gap-funding) for a roll-out project. The advantage here is that there is no further involvement by the public sector (with the possible exception of monitoring). Responsibility is handed over to the private sector. On the negative side, best bidder gap funding process can be ill-designed as the funding is neither operator-based nor takes into consideration sustainability as suggested by some commentators.¹⁶ Alternatively, a subsidy could be devised aimed at funding a passive infrastructure company. A grant or an equity participation could attract additional private investments. This would increase the overall available investments for NGA and offer an entry point for private investors.

Case 2: The project might be attractive but lacks critical size. Institutional investors do not have the resources to analyse the investment case.

Conclusion: As mentioned in 2. above, Knowledge Hubs are suited to leverage resources for project appraisal but even they will run into capacity constraints when dealing with too many and too small projects. Hence, state aid guidelines should be structured in such a way, and national and regional governments encouraged to provide incentives for projects to be aggregated. This could also support the monitoring of state aid projects, for example, as smaller projects might be too small to be subject to claw-back clauses. In cases where state aid is not applicable, economic policy has no immediate lever and it will be up to market and financial pressure to force an eventual lead to a more consolidated structure. This could imply that appropriate ownership and governance structures are implemented that do NOT prevent consolidation per se.

Case 3: The project is attractive and has critical size but external (esp. equity financing) capital is not welcome. This could hinder an acceleration of the roll-out or kill the project altogether. This mentality can be explained by the objective that the network should remain in full ownership of the public sector and/or the preference is to retain full control and limit financial transparency.

¹⁶ See, for example, http://www.uswitch.com/broadband/news/2014/04/pac_criticises_bduk_rollout/. According to the article, the UK „...Public Accounts Committee has issued a new report into the Broadband Delivery UK project, which claims that the £1.2 billion scheme has serious failings in terms of both competition and openness.“ Or http://www.kommune21.de/meldung_22351_Verbände+fordern+Weitsicht.html . In this article four German industry associations criticise the structural preference of the proposed German state aid programme in favour of traditional gap funding vs operator models and copper enhancements vs FTTB/H fibre solutions.

Conclusion: This case is similar to b). The role of economic policy is to enable or even encourage market entry by private firms and enforce cooperation where suitable. The Directive 2014/61/CE on broadband cost is a good example of this.

Case 4: The project could be attractive if restricted to wholesale-only and attracts service providers and wholebuy partners

Conclusion: This would mirror the trend in mobile market where mobile towers are an accepted infrastructure segment. *Technically*, this would require an industry-wide agreed set of standards and interfaces to allow all existing and new digital service providers easy access to wholesale-only networks. Enforcing such technical interfaces could be a prime objective for policymakers to realise the Single Digital Market. *Economically*, such a model could give rise to another layer in the value chain: specialised providers: they maintain a platform that enables the relationships between access seekers (ie. service providers) and utilisation maximisers (ie. the infrastructure companies). In principle, a number of scenarios are possible: passive infrastructure and active equipment is managed by the same company, management of the active equipment is outsourced to a further company or remains part of the solution portfolio of the platform operator. *Structurally*, specialisation could emerge as the financially-superior model and exert pressure on vertically-integrated players. We note that the wholesale-only model is closely related to the aggregation argument: the platform will only appeal to service providers if it can offer a minimum of accessible households. Economic policy could actively support these platform companies thereby guaranteeing non-discrimination.

All in all, it appears that two areas for economic policy emerge. First, there are roll-out areas that will never be economically attractive for a private investors. Subsidies are inevitable of NGA networks if the EC's Digital Agenda targets are not to be diluted. The main consideration then is how to design the allocation mechanism to ensure an effective and efficient use of taxpayers' money. We note that usually the provision of funds precedes the allocation decision. In contrast, we argue that the design of the allocation mechanism could lead to a much improved outcome. This could help to better position communication infrastructure in respect of other infrastructure segments so that the dramatic cut, related to the CEF, can be avoided in the future.

The second area for economic policy involves making available funds for projects that do NOT qualify for state aid such as that envisaged by the EFSI ('Juncker Plan') which suggests solving structural or regulatory problems with money. The old proverb „If you have a hammer, everything looks like a nail.“ comes to mind. In our view, capital is not the limiting factor and we think initiatives such as the Single Digital Market that addresses the legal framework, should be used to enable and encourage private investment processes to take place. Specifically, this should address issues such as openness of interfaces, project size and sustainability in scoring models covering state-aid supported projects. In our view, these measures should be considered; even if the EFSI garners some success the targeted €315bn funds will not suffice, as the EC itself concedes:

*„The European Investment Bank estimates that the EU may need up to €2 trillion in investment in the period up to 2020. Public support through measures such as the €315 billion Investment Plan for Europe (IP/15/5420) will help, **but there is a clear need for***

*more private investment in such projects in the longer term.*¹⁷

6. Financing models

We now turn our attention to financing models and, in our view, an area that deserves more attention if Europe is to achieve its NGA targets, especially in rural areas. All the models have already been proven in many industrial sectors, such as banking, renewable energy, housing and some of them even in broadband. Financing models can be supported by state aid or through EU funding but are not necessarily dependent on them. This section is not meant to give an exhaustive overview but bring awareness to alternative models in contrast to direct state aid (gap funding) and traditional bank debt.

The first three approaches are in the realm of social enterprises. These are undertakings „... whose primary objective is to achieve social impact rather than generate profit for owners and shareholders,

- which uses its surpluses, in the main, to achieve these social goals,
- which is managed by social entrepreneurs in an accountable, transparent and innovative way, in particular by involving workers, subscribers and stakeholders affected by its business activity.“¹⁸

Social enterprises exist in many different forms across Europe. These include traditional legal forms such as charities, associations, foundations, cooperative societies, share companies and newly designed forms like Societe Cooperative d'Interet Collectif s (SCICs) in France, Community Interest Companies in the UK.¹⁹

These forms differ with regard to the governance model, social objectives and capital finance. Below we shall discuss Community Shares, Social Impact Investments and Zweckverbände

Cooperatives – Community Share Companies/Genossenschaften

Every enterprise needs equity to start. Access to risk capital is a major obstacle for NGA projects in economically unattractive areas. A characteristic of these projects are that the number of households to be connected is relatively small. Projects can be labelled „bottom-up“ which is to say, that it is initiated locally with a community aspect. Cooperatives can be a mechanism to solve two problems in one go: raising capital and gaining subscribers. Likewise, subscribers can profit from two utility streams: appropriate financial returns and better connectivity.

Key features are:

- regulated legal structure with high degree of transparency
- proven in many economic sectors for more than 100 years
- one investor – one vote principle; this rules out unfriendly takeover scenarios

¹⁷ see http://europa.eu/rapid/press-release_MEMO-15-5734_en.htm

¹⁸ http://ec.europa.eu/internal_market/publications/docs/sbi-brochure/sbi-brochure-web_en.pdf

¹⁹ Many forms are very country-specific which limit comparability and renders a translation of some terms useless. So, the reader will find the original expression in the text.

- offers an intelligent marketing scenario for NGA access
- investment risk generally limited to initial backing
- investors can profit from dividends but not from value accretion
- shares are liquid and can be sold back at face value but do not trade on exchanges

In a study commissioned by the development bank of Northrhine-Westfalia²⁰, the consultancy firm MICUS proposed this model and has further developed it together with the *Westfälischer Genossenschaftsverband*. According to the authors of the report, the first model is being realised for a business park in Lennestadt, a smaller city east of Düsseldorf. Other similar projects are work-in-progress. Moreover, the Cybermoor Networks tried to raise capital from a community share offer; however, it is not entirely clear if the offer was a success²¹.

Social Impact Investments

How to bridge the interests of financial investors and those of society in general is a key issue of NGA projects in non-urban areas. Investors cannot, by definition, monetize the positive external effects that come along with better broadband connectivity that policymakers aim for. While a growing number of investors already take into account so-called ESG factors (Environment, Social, Governance), by and large this is achieved by ruling out investments in „unethical“ sectors or companies with „unethical“ business practices such as tobacco. Likewise, asset managers have launched „theme“ funds that seek exposure to sustainability ideas, renewable energy for instance. Another variant of ESG investing is impact investing. Impact investors specifically target ventures whose social and environmental results are positive and quantifiable or as the Global Impact Investing Network (GIIN) puts it as „...investments made into companies, organisations, and funds with the intention to generate measurable social and environmental impact alongside (!) a financial return.“

It is appealing to us to blend this general idea of impact investing with the modernisation of broadband networks in areas where a looming digital divide worries many policymakers. Additionally the idea of combining state aid with private capital investments is also a feasible option:

- This would make state aid more effective as capital providers are able to analyse the impact. Quantification is a key element of this approach. We view this as a wider, more society-oriented set of key performance indicators (KPIs). Interestingly enough, the GIIN has already defined Impact Reporting and Investment Standards (IRIS). These standards would have to be enhanced to reflect the specifics of NGA investments, this is common practice, for example, in the US which use industry generally agreed accounting principles (US GAAP).
- State aid could also be used more efficiently as investors will still remain interested as long as they receive a decent return. Thus, the overall impact could be optimised.

²⁰ Available for download on: <http://www.nrwbank.de/de/corporate/downloads/presse/publikationen/sonstige-downloads/Nachhaltiger-NGA-Netzausbau-als-Chance-fuer-Nordrhein-Westfalen.pdf>

²¹ A share offer document can be found here: http://www.cybermoor.org/images/cybermoor/Offer_Final_150608.pdf

- Such an approach would also support the public accountability of policymakers. The success or failure of policy measures could be judged more objectively. And last but not least, the proverb „what you can measure you can manage“ still holds and would give policymakers and project owners early signals to exercise options to abandon!

So far, we are not aware of any NGA project being directly classified as an impact investment. However, the report „Impact Investing – a framework for policy design and analysis“²² contains 16 case studies, at least two of which could be of direct relevance to FTTH: first, Community Interest Companies (CIC) and secondly, the Joint European Support for Sustainable Investment in City Areas (JESSICA)²³.

Zweckverbände (Germany), Gemeindeverbände (Österreich) oder Syndikate (Luxembourg)

These legal structures represent forms of communal cooperation which have mostly been involved in water utilities. The Zweckverband fibernet.rnk comprises 54 cities and counties and plans to roll-out an FTTB network over the coming years. Fibernet.rnk will only invest in passive infrastructure, other operations will be outsourced. The charter gives different sources of funding: an entry fee and regular contributions from participating cities and counties, state aid, debt capital and rental fees. In our view, this entity could be a prime target for impact investors. The charter contains an interesting clause: a potential profit will be distributed based on the number of homes, businesses or administrations connected. A footnote in the charter reveals that Fibernet.rnk primarily intends to use a special broadband facility from German KfW. In our view, such a project should be of interest to Social Impact investors.

Separation models

We now turn to bigger projects with social enterprise perspectives to a capital markets view (although some ideas could be applied to impact investing as well). Separation models have become more interesting as the low-interest rate has it made increasingly difficult for long-term investors to find attractive and predictable yields. To meet this interest, companies are able to separate stable cash-generating businesses from the company. The rationale is that investors will pay a premium for such businesses and the companies involved can re-structure and release capital.

There are many variants of separation, ranging from a partial sale (e.g. flotation of Inwit, Telecom Italia's mobile tower business) to spin-offs with exclusivity (e.g. the spin-off of CS&L from Windstream) or spin-offs without exclusivity (CETIN from O2 Czech or Chorus from Telecom New Zealand). In the renewable sector, the creation of so-called YieldCos follows the same logic. Other forms are Real Estate Investment Trusts (REITs, CS&L is an example) or Master Limited Partnerships (which were introduced in the US in 1987 to incentivise investments in infrastructure and receive). This type of company is important as they function as

²² Available at <http://www.thegiin.org/knowledge/publication/impact-investing-a-framework-for-policy-design-and-analysis>

²³ The German law governing feed-in tariffs (StrEG and EEG) is also featured as a case study. This law weighs on the German economy by more than €20bn annually. It is at least peculiar to note that a *fibre feed-in tariff* has not been considered so far (in fact, a proposal by Dr Neumann, Managing Director of the wik Institute at the time was dismissed).

a pipeline of investable projects for long-term investors: the sponsor company places operating assets with contracted revenues in a YieldCo. The YieldCo is then sold (e.g. via an initial public offering) to investors and proceeds can be used by the sponsor to develop other projects to maturity. Thus, the project risk is eliminated, the market risk is replaced by the counterparty's credit risk of the contracted revenues.

7. Recommendations

For network operators

1. We propose an active search for, and the development of, real options in deployment plans; we also recommend having these options valued. The real benefit of this exercise may lie in the process and not in the result: this will sharpen your senses what drives the value of your project.
2. When considering external equity financing you should be aware that professional equity investors will have already valued this option before entering into price negotiations. You might unintentionally sell a stake in your company at a discount as you failed to invest in real option analysis and/or do not fully understand interdependencies of contractual options.
3. A flexible capital structure should be designed in such a way that it addresses the four main aspects: governance, control, incentives and cash distribution. However, this is often easier said than done and needs close cooperation of strategy, business development and financial advisers. The capital structure can also change depending on company status. So debt could become equity (ex: coco bonds offered by banks) or shareholders could be offered pre-emption rights in the case of the separation of a stable cash-generating business.

For investors

1. Investors should test the management of a company if they understand the business operationally and financially. And in turn, management should demonstrate experience in network deployment and mid-to long requirements. A partner strategy should also be developed to gain support in marketing initiatives and a scenario analysis should cover a broad range of contingencies and be included in the financial model.
2. Investors should be prepared to take an active and supportive role in the development of the undertaking, this relates to both social and 'normal' enterprises. A good understanding of the sector, technology and demand trends is a good starting point.
3. We strongly recommend that investors ask for a wholesale-only or infrastructure-only business case, if not already available. The comparison of an integrated and a separated model should work as a reality check for either model.

For policymakers and regulators

1. As capital is not the bottleneck factor in the funding of NGA networks, broadband policy should concentrate on pillar 3 of the EU Investment Plan: Improve the Investment Environment. This includes reducing government ownership in incumbents to zero. Structural changes will give new impetus to market-based solutions. Moreover, it has become increasingly clear that broadband

policy also involves, for example, financial market regulation that does not go against long term investment in sustainable infrastructure. What is needed is state aid for economically unattractive regions and allocation mechanisms to minimise state aid so that limited funds can be more effectively used.

2. Broadband policy should help turn often unsupported synergies into reality. Finding synergies is an obvious option to expanding. In general, synergies in the roll-out have been elusive. Standards can help to solve this problem, for example, in regard to deployment of empty duct systems or dark fibre. Network companies will not exercise this option if the passive infrastructure appears useless. Many good ideas already exist in the Cost Reduction Guidelines, their implementation by national government will be the litmus test.
3. A functioning secondary market for telecom infrastructure will encourage banks to accept network assets as collateral. This would be positive for two reasons: debt financing would be easier and the value of the option to abandon would increase making the overall investment case more attractive.
4. Having the discretion to wait, may be deemed positive by the option owner, however it could also prove detrimental to infrastructure competition: Another view is that vectoring regulations, for example, and the eligibility of vectoring for stated aid can be seen as granting the company that builds out vectoring an option to wait. As a corollary, this renders expansion options, owned by competitors, worthless.
5. To circumvent these problems, regulations should ensure that competitors have the choice to overbuild FTTC infrastructure. Easy access to this network at fair and reasonable prices (attractive strike prices in option terminology, enforced by regulation) is essential. Regulators should investigate if access to this fibre infrastructure is granted at reasonable terms and conditions. And, if claims by incumbents that investment in FTTC can be reused for FTTB/H, this should be easy to accomplish.
6. Broadband policy should enable and support aggregation platforms that make many smaller networks accessible for large service providers. This can be a business model in itself and could even be supported with equity funding from the EU.
7. Compound and growth options are the most interesting options for economic policy. They can stimulate equity capital and pave the way for more economic growth in the future. Hence, the screening process for communication infrastructure projects by development banks should take this into consideration. Networks should be seen as a platform for new business opportunities, or in other words, growth options for start-ups.

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Appendix A: Broadband targets in Europe

Country	Broadband Targets	Date
EU 	Fast broadband by 2020: broadband coverage at 30 Mbps or more for 100% of EU citizens	2020
EU 	Ultra-fast broadband by 2020: 50% of European households should have subscriptions above 100Mbps	2020
Austria 	Austria's broadband strategy 2020 <ul style="list-style-type: none"> • 100 Mbps for 70% of households until 2018 • 100 Mbps for 99% of households until 2020 	2020
Belgium 	"Digital Belgium" no long-term aims	2020
Bulgaria 	National broadband strategy: development in the country from 2012 to 2015 with links to 2020 <ul style="list-style-type: none"> • 100 Mbps for 50% of households 	2020
Croatia 	Croatian Broadband strategy <ul style="list-style-type: none"> • 30 Mbps for 50% of the population 	2020
Cyprus 	Digital Strategy <ul style="list-style-type: none"> • 100 Mbps for 50% of households and enterprises 	2020
Czech Republic 	National strategy <ul style="list-style-type: none"> • 30 Mbps for 100% of households and enterprises • 100 Mbps for 50% of households and enterprises 	2020
Denmark 	Danish broadband strategy <ul style="list-style-type: none"> • 100 Mbps for 100% of the households and enterprises 	2020

Estonia 	Estonian Broadband Development Foundation <ul style="list-style-type: none"> • Full coverage with connections of at least 30 Mbps • Ultra-fast subscriptions with at least 100 Mbps 60% HH 	2020
Finland 	National broadband strategy <ul style="list-style-type: none"> • 30 Mbps for 97% of the households 	2020
France 	National broadband strategy <ul style="list-style-type: none"> • 100 Mbps for 100% of households until 2022 	2022
Germany 	Germany's broadband strategy <ul style="list-style-type: none"> • 50 Mbps to all households 	2018
Greece 	National Broadband Plan NGA 2014-2020 <ul style="list-style-type: none"> • Objective 1: by 2020 online availability with access speeds of over 30 Mbps for all • Objective 2: by 2020, at least 50% of households should have an internet connection with speeds exceeding 100 Mbps 	2020
Hungary 	Broadband strategy Bulgaria <ul style="list-style-type: none"> • 30 Mbps for 80% of the population • 95% of households and 100% of enterprises and public facilities 	2018
Ireland 	Ireland's national broadband strategy <ul style="list-style-type: none"> • At least 30 Mbps for 100% of the population, households, enterprises and public facilities 	2020
Italy 	Italian ultra-fast broadband national strategy <ul style="list-style-type: none"> • At least 100 Mbps coverage for up to 85% of the population • At least 30 Mbps coverage for 100% of the population 	2020
Latvia 	National broadband plan of Latvia <ul style="list-style-type: none"> • NGA: 100 Mbps for 50% of households 	2020

Lithuania 	Lithuania's Next Generation Internet Access <ul style="list-style-type: none"> At least 30 Mbps for 100% of the population 50% of households using 100 Mbps or faster internet access 	2020
Luxembourg 	National plan aims for networks with ultra-high-speed rates <ul style="list-style-type: none"> 1 Gbps for 100% of the population 	2020
Malta 	Digital Malta Strategy <ul style="list-style-type: none"> 100% coverage with 30 Mbps broadband 50% of households with subscriptions over 100 Mbps 	2020
Netherlands 	Digital Agenda for the Netherlands <ul style="list-style-type: none"> 100 Mbps for 50% of households 	2020
Norway 	National Broadband Plan Norway <ul style="list-style-type: none"> 100 Mbps for 90% of households 	2020
Poland 	National broadband strategy Poland <ul style="list-style-type: none"> 100 Mbps for 50% of households and enterprises 	2020
Portugal 	Portugal's national broadband strategy <ul style="list-style-type: none"> At least 30 Mbps for 100% of the population At least 100 Mbps for 50% of households	2020
Romania 	Romania's existing national broadband plan <ul style="list-style-type: none"> 100 Mbps for 50% of the households 	2020
Slovakia 	National broadband strategy Slovak Republic <ul style="list-style-type: none"> 30 Mbps for 100% of the population 	2020
Slovenia 	Slovenia's current national broadband strategy <ul style="list-style-type: none"> Over 30 Mbps for 90% of the population 	2020
Spain 	Digital Agenda for Spain <ul style="list-style-type: none"> 30 Mbps for 100% of the population until 2020 	2020

Sweden 	Sweden's current national broadband strategy <ul style="list-style-type: none"> • 100 Mbps for 90% of households and enterprises 	2020
Switzerland 	Switzerland ultra-fast broadband strategy <ul style="list-style-type: none"> • At least 100Mb/s to 80% of the population 	2020
United Kingdom 	Digital Communications Infrastructure Strategy UK <ul style="list-style-type: none"> • Access to superfast broadband for 95% of the premises with 24 Mbps 	2017

Written January 2016

Appendix B: List of Telecommunications Regulators by Country

Country	Name of Regulator	Abbreviation
Austria	Rundfunk und Telekom Regulierungs www.rtr.at	RTR
Belgium	Institut Belge des services Postaux et de Télécommunications www.bipt.be	BIPT
Bulgaria	Communications Regulation Commission www.crc.bg	CRC
Croatia	Hrvatska agencija za poštu i elektroničke komunikacije www.telekom.hr	HAKOM
Cyprus	Office of the Commissioner of Electronic Communications and Postal Regulation www.ocecpr.org.cy	OCECPR
Czech Republic	Český telekomunikační úřad www.ctu.cz	CTU
Denmark	Telestyrelsen - National Telecom Agency www.itst.dk	NTA
Estonia	KONKURENTSIAMET www.konkurentsiamet.ee	KONKURENTSIAMET
Finland	Viestintävirasto Kommunikationsverket www.ficora.fi	FICORA
France	Autorité de Régulation des Communications Electroniques et des Postes www.arcep.fr	ARCEP
Germany	Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen www.bundesnetzagentur.de	BNETZA
Greece	National Telecommunications and Post Commission www.eett.gr	EETT
Hungary	Nemzeti Hírközlési Hatóság www.hif.hu	NHH
Iceland	Póst- og fjarskiptastofnun www.pta.is	PTA
Ireland	Commission for Communications Regulation www.odtr.ie	ComReg
Italy	Autorità per le Garanzie nelle Comunicazioni www.agcom.it	Agcom
Latvia	Sabiedrisko pakalpojumu regulesanas komisija www.sprk.gov.lv	SPRK
Liechtenstein	Amt für Kommunikation www.ak.llv.li	AK

Country	Name of Regulator	Abbreviation
Lithuania	Ryšų reguliavimo tarnyba www.rtt.lt	RRT
Luxembourg	Institut Luxembourgeois de Régulation www.ilr.lu	ILR
Republic of Macedonia	Agency for Electronic Communications www.aec.mk/eng	AEC
Malta	Malta Communications Authority www.mca.org.mt	MCA
Netherlands	Onafhankelijke Post en Telecommunicatie Autoriteit www.opta.nl	OPTA
Norway	Post- og teletilsynet www.npt.no	PT
Poland	Urzędu Komunikacji Elektronicznej www.uke.gov.pl	UKE
Portugal	Autoridade Nacional de Comunicações www.anacom.pt	ANACOM
Romania	Autoritatea Națională pentru Administrare și Reglementare în Comunicații www.ancom.org.ro	ANCOM
Slovak Republic	Telekomunikacný úrad Slovenskej republiky www.teleoff.gov.sk	TO SR
Slovenia	Agencija za pošto in elektronske komunikacije RS www.apek.si	APEK
Spain	Comisión del Mercado de las Telecomunicaciones www.cmt.es	CMT
Sweden	Post- och Telestyrelsen www.pts.se	PTS
Switzerland	Office fédéral de la Communication www.bakom.ch	OFCOM
Turkey	Bilgi Teknolojileri ve İletişim Kurumu www.tk.gov.tr	BTK
United Kingdom	Office of Communications www.ofcom.org.uk	Ofcom

Additional references and information sources:

<http://berec.europa.eu/> BEREC – Body of European Regulations for Electronic Communications

<https://ec.europa.eu/dgs/connect/en/content/dg-connect> European Commission, Directorate General Connect

Appendix C: Glossary

ADSL	Asymmetric Digital Subscriber Line
ARPU	Average revenue per user
CAPEX	Capital expenditure
CO	Central office
CPE	Customer premises equipment
DOCSIS	Data Over cable System Interface Specification – a cable TV network solution
DSL	Digital Subscriber Line
EBITDA	Earnings before interest, tax, depreciation and amortization
FTTH	Fibre-to-the-home
FTTx	Fibre-to-the-x – any type of fibre access network architecture
GPON	Gigabit Passive Optical Network – shared fibre access network architecture (ITU-T G.984)
HD TV	High-definition television
ISP	Internet service provider
IRR	Internal rate of return
LLU	Local loop unbundling
Mbps	Megabits per second – a measure of data transmission rate
MDU	Multi-dwelling unit – an apartment block
NPV	Net present value
NRA	National regulatory authority
OLT	Optical line terminal – the PON equipment in the central office
ONT	Optical network termination – equipment terminating the fibre in the subscriber's home
ONU	Optical network unit – generic term for equipment terminating the fibre in a subscriber's home or building
OPEX	Operational expenditure
OSS	Operations support system
PON	Passive optical network
POP	Point of presence – the FTTH equivalent of a telephone exchange
ROI	Return on investment
SMP	Significant market power
VDSL	Very-high bit-rate Digital Subscriber Line
VoIP	Voice over Internet Protocol
WACC	Weighted average cost of capital
xDSL	x Digital Subscriber Line (of any type)

Appendix D: White Paper

FTTH: Shaping the Future of a Content-based World

Telecom operators, application and content providers have come a long way in building relationships with each other in recent years.

Yet the next major investment in Europe's broadband networks will demand even more: The future of Europe's broadband infrastructure depends on further collaboration between application and content providers and telecom operators and a deeper understanding of how they interplay to each other's benefit.

The last decade illustrates how a mixture of innovation in broadband communications and IT can rapidly reshape how society communicates, works and entertains. But we are on the brink of much greater change. Ongoing innovation in the fields of nano technology, biotechnology and computing promise to radically alter the way we use, design and distribute goods, health care, education, entertainment and communication services.

After all, few people building power stations in the early 20th century could have imagined the extent to which electricity networks would drive new industries for domestic appliances and revolutionise housework. Fortunately the creators of yesterday's power generators laid an infrastructure that could accommodate a century of growth.

Today's investors in broadband need to take a similar leap and create a sustainable, flexible infrastructure that can accommodate new, unexpected services and ways of doing business.

In this White Paper we will look at how very high-speed FTTH access is needed for innovative and diverse services and create the potential for new businesses and mutually beneficial interaction between diverse sectors.

Back to the Future

Internet history reveals a strong correlation between how much bandwidth consumers have at their disposal and the development of content, service and device ecosystems. Whole new communication and business models have been made possible by increases in broadband access speeds.

Back in 1996, CEO's from major software companies, including Oracle, put forward the idea of network computing, which is the storing and running of applications on a server in a network. The idea was great, but dial-up Internet speeds were not. The concept of network computing was shelved.

Fast forward over a decade and the accessing and sharing of resources on servers in a network – or cloud computing -- is becoming a reality for users equipped with very high speed broadband.

Striking changes in communications usage have also taken place in the home. Over a decade ago, receiving a phone call when online usually resulted in a dropped connection.

Consumers today would balk at such levels of service. Instead their requirements are growing in line with the simultaneous use of several residential broadband applications. And there is every sign that consumers' demands will grow, with the next stage in delivering content and interactive video broadband services requiring more capacity than today's legacy networks can provide. If service providers are to avoid their subscribers cancelling their subscriptions and going to the competition, then they will need to invest in infrastructure that can cope with huge capacity requirements from both fixed and wireless usage.

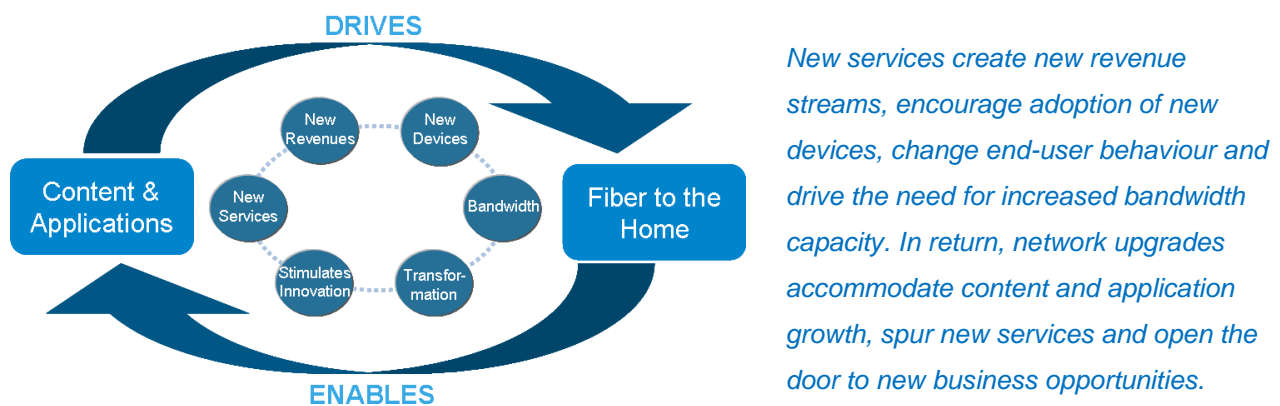


Figure 6: The evolution of services and bandwidth is closely connected

People have also benefited when on the move. Clever marketing and design helped put smartphones where they are today, and a mini mobile computer would be much less practical without the last decade's constant rise in wireless network speeds. But mobile operators cannot squeeze capacity from their networks, indefinitely: continuing growth in mobile data usage places constraints on wireless networks, which need to be alleviated by local fibre access networks. Not only does fibre provide backhaul from base stations, Wifi, 3G and 4G can be integrated with an FTTH installation to provide full wireless coverage throughout the home. In this way consumers can connect several wireless devices running HD or 3D video via Wifi to the FTTH network, allowing mobile operators to lift the strain on their mobile infrastructure and offer a sophisticated array of broadband services. FTTH takes residential users far beyond simple triple-play and opens the door to the concurrent use of multiple high-bandwidth applications.

New Investors in Infrastructure

Today most consumers' upload capacity is a small fraction of their download speeds. A large jump in two-way bandwidth capacity in the form of FTTH promises to unlock a raft of new applications that will benefit consumers, businesses and the suppliers of content, health and education services.

Practically unlimited capacity enables several members of the family to use high definition video applications simultaneously, whether they are watching TV, playing a 3D video game, making a low latency video call to a friend, consulting with a doctor, or posting film clips to social networks. Residential fibre networks will also

open up new uses of cloud computing and enable a more flexible and creative approach to work. Not only will home-workers be able to quickly access shared enterprise applications, high upload speeds will make it practical to send, store and share large files of video, music and photos in the cloud. Meanwhile, small businesses will be able to work collaboratively online with suppliers and customers around the world in ways that are today only possible for larger enterprises equipped with fibre access.

FTTH represents a genuinely new platform for creating a real change in broadband usage, which in turn can spur service innovation that leads to socio-economic benefits. This is the reason why municipalities and utility companies across Europe have been among the first investors in FTTH networks. Municipalities see FTTH as an opportunity to lower the cost of providing key services such as healthcare and education to their citizens, while improving their quality and reach. Municipalities also realize that FTTH attracts companies to set up in their region.

Utilities, meanwhile, see in FTTH an opportunity for additional revenue streams by complementary investment to prime business and become the unique wholesale broadband provider to residential dwellings. Not only are utilities used to making long-term infrastructure investments, they also have experience in providing open access to third parties. In addition, utilities already provide services such as water and electricity to apartment blocks and individual dwellings, making them well placed to negotiate access to buildings with landlords and building managers.

Meanwhile, FTTH benefits property owners, who will be able to improve the rental or sale value of dwellings that are hooked to future-proof fibre networks. They can also use FTTH networks to increase security, by installing the video-based surveillance of communal spaces, such as hallways, car parks and stairwells. Recent investments in FTTH come amid an increasingly competitive broadband environment. Europe's cable operators, for example, are busy equipping their networks with Docsis 3.0, which provides downstream speeds of between 100Mbps and 300 Mbps. Yet even cable and DSL network operators that are making upgrades to prolong the life of existing networks see fibre as the target solution. So it comes as little surprise that a number of European telcos are starting to up the ante on FTTH deployment. Deutsche Telekom, for example, announced in August 2011 the establishment of a FTTH unit, with a budget of €1.5 Billion, approximately 1500 employees and an objective of connecting 160,000 households by the end of 2011.

Investing in Innovation

Players with little or no experience of investing in infrastructure are also showing interest in developing FTTH delivery platforms. Large as well as small content and application companies are fully aware of the business potential of a two-way very high speed broadband network. In April 2011 Google announced it would build and trial a FTTH network that delivers speeds of up to 1Gbps and involve as many as 500,000 subscribers, starting in Kansas City, Kansas. In July 2011, the first users were already being connected. Like many telecom operators, Internet companies combine a powerful brand with a large user base. They and other forward-thinking companies that see their future in two-way high speed video usage could potentially pursue FTTH investments which dis-intermediate operators.

Equally they could choose to continue to play to their strengths and instead partner with network operators on delivering new services. Today's telecom operators combine a billing infrastructure with IT expertise, a large, national customer base and a reputation for safe-guarding end-consumer privacy, which make them well placed to work with health authorities, insurance providers, schools, universities and content and application companies alike.

Home Networking

FTTH allows operators to enrich their triple-play offerings today, while laying the foundations for the entertainment and home management network of the future. The ongoing moves to develop e-education, e-health and e-administration services, combined with the increasingly intelligent home devices creates new business opportunities for telecom operators, energy companies, electrical goods and device manufacturers, broadcasters, film distributors and content and application service providers. To date telcos such as Orange in France have collaborated fruitfully with content providers on video-on demand and television services, as digital downloads become an increasingly important channel for film distributors. The market for transactional movies grew by 38% year-on-year in 2010, with digital rental increasingly becoming consumers' favoured way of consuming films, according to the film and broadcasting research company, Screen Digest. FTTH will serve to strengthen the relationships between the producers of video content and network operators and provide the bandwidth capacity to investigate new business models. Service providers, for example, will be able to offer 3D video-on-demand and television programming, or semi-immersive online gaming.

In addition, FTTH's large upload capacity opens up the potential to offer new low-latency, high-quality video services, alongside home management and surveillance services, as well as e-health and e-education.

Already a number of major Internet companies are busy providing video-conferencing platforms to consumers.

In June 2011 Facebook and Skype, announced a tie-up to provide a social-networking video application. The companies initially will make a low-quality video calling facility available from within Facebook, which will encourage video communication between Facebook users. The move follows Google's development of an online multi-user video-conferencing application, called 'Hangout', which is part of its social network Google+.

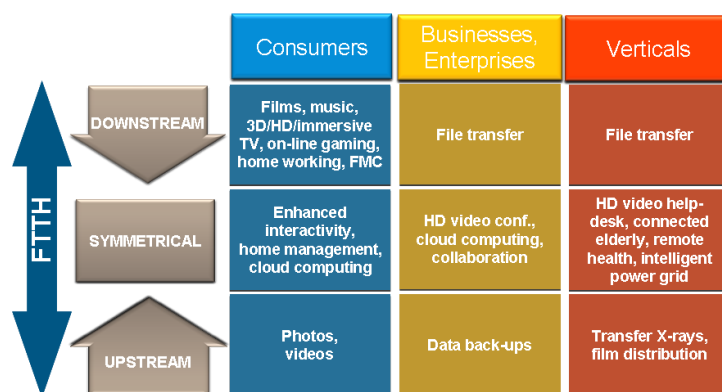


Figure 7: Technical Requirements for Next Gen Services

Bandwidth requirements for all segments of end-users are set to grow rapidly, in line with the availability and adoption of new services. Cloud based applications; video streaming, large file sharing etc. are pushing today's bandwidth boundaries both in upstream and downstream direction. Although available bandwidth is an important network requirement for next gen services - it is not the only one. In cloud computing, where information can be stored anywhere in the world, low latency is one of the critical requirements. Only fibre to the home fulfils these requirements and future-proofs operators against a cycle of network upgrades.

Google and Facebook will not be the last word in consumer video-conferencing, telcos could look to make the most of their strong brands and reputation for high quality of service to offer high-quality video-conferencing over FTTH, either alone, or in conjunction with third parties. Further possibilities for new business ventures will open as screen prices fall to levels where they can be placed liberally around the home, enabling instant photo downloads to screens, or video-conferencing facilities in multiple rooms.

Telcos' direct relationships with a large client base make them attractive partners for content and application companies, as do telcos' existing billing platforms to charge for premium programming, games and applications. Secure fibre networks can also help protect content from piracy and telcos can make available their retail outlets, as well as their national customer support systems for both sales and resolving enquiries related to third-party services. In return, telcos gain access to premium, differentiated content and services, which allows them to win new subscribers and grow revenues.

Workplace revolution

Of course the transformational effects of broadband reach far beyond an individual's personal sphere. Today's broadband infrastructure already enables individuals to connect and do business with a global network of companies, from home or the office. The resulting flexibility in working practices benefits employers, employees and contractors alike.

Yet the next step change in how companies and workers collaborate will require FTTH.

Very high-speed fibre broadband, for example, lets companies and individuals use shared cloud computing resources to remotely access heavy-duty enterprise applications. This not only further facilitates home-working, it also opens new ways for knowledge workers around the world to interact with large companies and each other. Cloud computing also creates cost-effective methods of sharing huge computational resources for research and development projects, regardless of where participants are based.

Many application, telecom and service companies have already developed cloud computing applications. However, it is still early days for cloud computing, leaving open opportunities for innovative cross-sector collaboration between software companies, systems integrators and others, in order to better serve subscribers.

In addition FTTH will give companies of all sizes the means to use secure, private, high quality video-conferencing facilities. As a result employees and contractors will be able to communicate with multiple parties in various locations around the world.

Again, no one company holds all the pieces that will create the new working environment of tomorrow. Telcos, however, have built strong reputations for providing enterprise-strength applications making them well-placed to collaborate on offering the next generation of secure remote enterprise services.

Transforming healthcare

Security and reliability will be crucial to an additional important role for FTTH, this time in the distribution of health services.

Governments faced with ageing populations are looking for cost-effective ways to use IT and telecom networks to provide care and monitoring to the growing numbers of the chronically sick and elderly.

This shift means private companies, including telecom operators, software firms, health equipment suppliers and insurance companies, are working with health authorities to create e-health applications that greatly improve efficiency without dehumanising, or reducing the quality of patient care.

Low latency high quality video-conferencing, for example, allows patients to interact directly with care-givers, doctors and nurses, without having to undertake long journeys.

In Sweden, the nurse Gudrun care channel provides patients with online video consultations over their TV sets, thereby reducing out-patient visits and saving both patients' time and public money. As such e-health applications develop, FTTH will allow HD quality video-conferencing, regardless of whether others in the home are using online applications. A telepresence-like HD video connection not only maintains the caregiver-patient relationship, it offers key visual clues of a patient's state of health. Such services are of particular benefit when patients may be far from specialist care. But video services are also of use to patients who prefer to return home to recover from a medical intervention, yet still need to consult face to face with their doctor.

And as e-health services evolve, FTTH's almost unlimited capacity can allow for an increasingly sophisticated video exchange between a patient at home and multiple health service providers, in addition to an exchange of patient data.

In addition hospitals, which are already equipped with fibre networks, will be able quickly share huge files, such as scans with general practitioners equipped with FTTH, while discussing a patient's diagnosis via a video-conference. E-health applications mean working adults suffering from chronic diseases such as diabetes, can conduct check-ups online, rather than taking precious time off work to wait for consultations in doctors' surgeries, or hospitals.

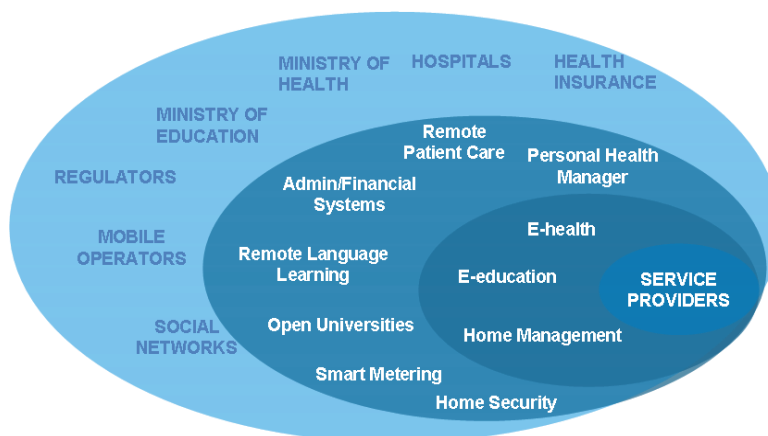


Figure 8: Collaboration between service providers and different stake holders will further drive richness of Next Gen Services

Although e-health is still an emerging service in most markets today, many agree about its benefits: cost efficient, enhanced quality of care, tailored to the individual, educational, extending the geographical boundaries... And this is just the beginning. In order to fully enjoy the benefits of e-health, more collaboration will be needed from different health care players to provide secure internet-based technologies and services that support remote patient care, medical records and decision support tools. Stakeholders will need also to work together to improve computer literacy of e-health consumers and enforce laws to protect the privacy and confidentiality of data. Once hospitals, insurance companies, health and education government institutions join in offering comprehensive e-health service, it will become clear why "e-Health is the single-most important revolution in healthcare since the advent of modern medicine, vaccines, or even public health measures like sanitation and clean water" (Silber, 2003).

Similar changes could be expected in e-education. One vision is that in the future students could follow individual classes from different Universities and lecturers all over the world. This type of educational system is tailored to fit personal and professional individual interests, but would require the involvement of government educational institutions to address questions such as education program recognition and diploma certification.

Other video-based health care applications include physical rehabilitation systems that run over high-speed broadband, which allow patients to practice movements while imaging sensors pick up any mistakes.

Telecom operators equipped with both FTTH and a trusted consumer brand are well placed to partner with health service providers and insurance companies to deliver health services.

Video exchange brings health benefits that are less direct, but important nonetheless: Elderly tech-savvy baby-boomers will be able to use HD or even 3D video conferencing and other communication tools that enable a real time experience when keeping in touch with each other and their families. The independence that a very high speed broadband infrastructure offers means elderly people could stay longer in their own homes, particularly when the benefits of video social networking are bolstered by personal, professional health care.

Home Study

FTTH will power other positive social changes, which in turn will spur new business opportunities. Very high-speed networks, for example, have a clear role to play in providing interactive e-education.

Bill Gates forecast that *“five years from now on the web for free you’ll be able to find the best lectures in the world,”* when speaking at the 2010 Techonomy conference. *“It will be better than any single university.”*

But it won’t stop there. E-education can take several forms. Students may simply cherry-pick the best online lectures from top university teachers around the world. Equally, parents may opt for distance-learning when seeking to home-tutor secondary school students.

High-quality interactive video transmission could open new possibilities for teaching the practical elements of science. Or e-education could provide the means to access over-subscribed workshops, lectures and visits run by leading arts schools, or museums. In the meantime, entrepreneurs are already busy setting up companies that combine elements from the fields of education, entertainment and gaming in order to create new forms of engaged, interactive learning. None of this can be done by one company alone. Instead, educational services create fertile ground for several actors to come together to deliver their expertise across very high speed FTTH networks.

Collaborating for the Future

As Google’s FTTH investment in Kansas illustrates, in order to fully understand the potential of FTTH, it is necessary to consider what happens once more than 20% of a sizeable population has access to two-way, very-high speed broadband access. Yet revenue pay-offs can come long before network expansion is complete. At the end of 2010 Verizon in the US reported ARPUs increase for its FTTH FIOS service, up 4% from the previous year. The operational benefits of fibre network and richness of services that creates additional revenues resulted in an overall annual rise in FIOS revenues of 26.8% and Verizon confirmed it plans to continue expansion of its FIOS network through 2011.

In Europe, larger-scale deployments of FTTH by private operators are only now getting underway.

However, municipalities in Sweden, the Netherlands and France have built FTTH networks, which already offer a glimpse of what can be done once enough subscribers exist to encourage innovation by content and application companies.

The town of Nuenen in the Netherlands, for example, is home to one of the world's highest FTTH densities and has linked its elderly population over high-speed networks to create a video-based platform of community exchange. The social benefits to Nuenen's elderly of reducing solitude by fostering exchange are immeasurable. The platform also gives an inkling of how social video networks could develop once two-way bandwidth is almost unlimited.

Widespread FTTH networks not only offer a wealth of new service opportunities, they also promise to reduce operators' maintenance and operation expenditure. Nevertheless some of Europe's telcos today are approaching FTTH investment cautiously. Although telecom operators recognize fibre to the home as the network of the future, some still question the extent to which they will benefit directly from their investment in tomorrow's very-high speed broadband networks.

Despite concerns over how actors will share both the cost of infrastructure and the benefit of new revenue flows, it remains in everyone's interest that FTTH networks are built. Telcos will be able to offer new, differentiated products and reduce the congestion on their networks that the growing consumer demand for HD video streaming and fixed-mobile convergence brings. Content, Internet and application companies will be able to create truly interactive products and services. And not building FTTH networks puts today's owners of copper networks at risk of falling behind competing mobile and cable network operators.

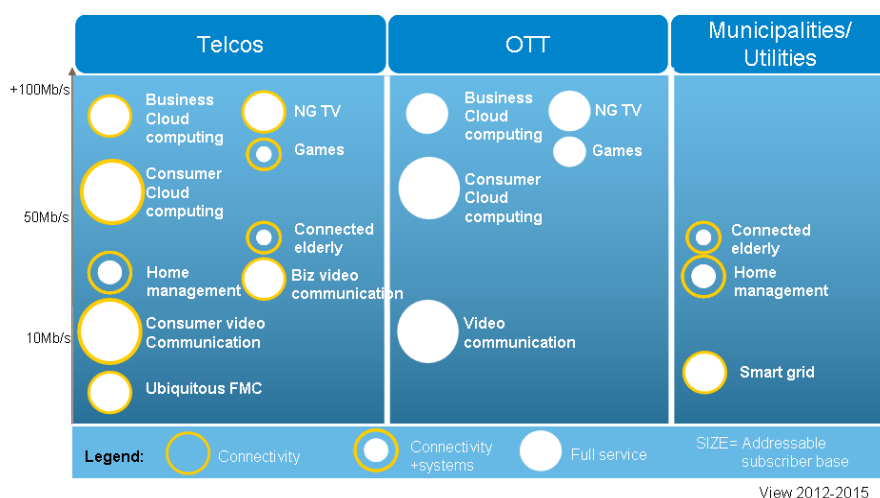


Figure 9: Next Generation Services Value Proposition

A new generation of content and applications opens opportunities for all players to engage on different levels in defining the best business model. The value proposition of different services is based on their market potential, revenue opportunity and end-user requirements such as security, privacy, reliance, cost vs. quality preference etc.

Despite concerns over how actors will share both the cost of infrastructure and new revenue flows, it remains in everyone's interest that FTTH networks are built. Telcos will be able to play on their strong customer

relationships and branding to remain prime provider of new, differentiating products and at the same time reduce the operating costs. Content, Internet and application companies will see the opportunity for raising revenues and developing new services. Utilities will be able to get additional revenue streams from investments that complement their prime business. And not building FTTH networks puts today's owners of copper networks at risk of falling behind competing mobile and cable network operators.

However, if telcos are to invest alongside utility companies and municipalities in building the content and application delivery infrastructure of tomorrow, then all potential actors need to collaborate on building a vibrant, mutually beneficial business model today.

It is Time for Change

Consumers and businesses the world over have been quick to view any new broadband capacity as an essential part of their social and economic fabric. Cloud based services and the internet of things – i.e. the communication between billions of sensors, which enable new and exciting applications – will accelerate broadband adoption. But the broadband adoption is not only fast and massive – it is also addictive: 84% of Germans in their 20s would rather give up their car or partner than their broadband connection ⁽¹⁾; 41% of UK internet users would rather keep Internet connection than TV ⁽²⁾. And consumers are not about to become less dependent on broadband. The social network revolution has re-shaped consumer broadband behaviour; today's emerging generation of broadband users manage and conduct their social life around online connections. The next big changes will be in the online distribution of health, education and energy services, as well as the development of smart cities.

Today's increasing richness of new applications and its value for our way of living, puts the power to shape future broadband usage in the hands of consumers, rather than telecom operators. Today's networks need to be ready for rapid change. And operators and other stakeholders need to prepare for a future that is not just about providing telecom services, but building an engine for socio-economic development.

⁽¹⁾Bitkom 2011 - http://www.ehow.com/facts_5201693_types-broadband-access.html

⁽²⁾ <http://moneyfacts.co.uk/news/broadband/internet-users-willing-to-sacrifice-tv/>

Appendix E: FAQs

Deploying Fibre-To-The-Home today...

“The 10 most frequently asked questions”

Demystifying the deployment (and adoption) of Fibre-To-The-Home

Today, telecommunication market players such as traditional operators, municipalities, utility companies or organisations leading individual initiatives, are seeking to offer high speed access to their end-users, be it in residential or enterprise environment.

This document intends to give more guidance on the main activities one encounters with the deployment of “Fibre-To-The-Home”. Successful FTTH deployment and adoption encompasses a stepwise approach of thinking, analysing, implementing and enabling: starting from the initial business case (justifying the Return on Investment (financially or socially)) and ending by the final adoption of the service by the end-user.

Issues and solutions are illustrated by means of 10 main questions with respective answers and cover FTTH deployment and provide clarification of some topics with practical examples. Let this document be a first introduction and sanity check on your ideas for FTTH.

Below are the 5 steps of FTTH deployment:

1. Prepare and keep detailed documentation of all decisions (go or no go?)

Design the business case, specify the geographic market, concretise your business model, choose a network architecture and check regulatory obligations and requirements.

2. Deploy your outside plant (put your fibre in)

Perform the dimensioning of your passive infrastructure, select your components, perform cost synergies, and implement your fibre termination

3. Implement your connectivity (light your fibre)

Deploy your active technology, respond your time to market needs, perform interoperability and end to end testing and implement your management solution

4. Enable your service directly to the end-user (retail?)

Launch your service bundles, organise your customer support, manage your end-user’s home environment

5. Enable service models with third parties (wholesale?)

Expand beyond your traditional 3play services, negotiate quality of service agreements and promote application stores

Step 1: Prepare and keep detailed documentation of all decisions (go or no go?)

Ensure all parameters are specified, for making a sound judgement. Why, when, where and how do we go for it? Only the best plan will lead to the better outcome. Some questions:

Question: Which geographical area(s) do you consider for the FTTH deployment?

Different criteria (socio economics, expected take rate...) can be used to select the geographical areas for the FTTH roll-out. Given a certain investment budget, one can opt, for instance, to maximize revenue generation or to realize maximal coverage.

For that purpose, geo-marketing techniques, based upon socio-economic data within a geographical context, are used for the initial network design and for calculating the related business case.

Question: Do you consider partnerships? Which partners can you engage with?

Partnerships are established to deal with the huge investment costs in fibre infrastructure and/or to meet the challenge of the successful exploitation of a FTTH network.

The big difference in investment budget, life cycle and risks between the active and passive fibre infrastructure, requires long-term partnership agreements on the operational and business aspects. More specific a fair revenue sharing model has to be worked out, to come to a sustainable business model for all involved partners.

Additional questions:

Question: What is a reasonable “payback period” for FTTH investments?

Question: Can you benefit from an “open network” and how do you concretise?

Question: What basic network design and modelling should you do?

Step 2: Deploying the outside plant (put your fibre in)

The passive infrastructure is the foundation of the FTTH rollout. Consider the best options and anticipate cost-effective implementation. Additional questions:

Question: Are cost synergies possible (imposed or not by regulation) with other infrastructure operators in the public domain?

In general, considerable cost savings can be realized through a better coordination of civil works in the public domain. For that purpose, infrastructure builders are incorporating GIS (Geographical Information Systems) - based network design together with planning and documentation tools. This facilitates the exchange of public infrastructure information and offers a more synchronized workflow management between the various infrastructure builders. Field practices have shown that the cost per Home Connected/Passed can be further decreased with improved OSP project management.

After the deployment phase, a well-documented as-built outside plant leads to less fibre cuts, helpdesk calls and better trouble shooting in case of failure.

Question: What criteria should be used for the selection of passive components such as ODF, cables, enclosures, splices etc...?

As the lifecycle of the passive infrastructure is a multiple of the active technology lifecycle, it is essential to select qualitative passive components which meet future technology requirements (e.g. NG PON). A trade off should be made between the cost, quality and the labour related aspects (intensity and skills/tools required) of the components.

Other questions:

Question: What are the hurdles for in-house fibre wiring?

Question: What is the impact of local regulation?

Question: What dimensioning rules should be considered for the passives?

Step 3: Implementing connectivity (light your fibre)

Connecting subscribers involves employing the necessary bandwidths within the FTTH infrastructure. The active network and related technologies will cover that area. Additional questions:

Question: Choosing active technology?

Although fibre technology is subject to rapid evolution, the reality is the market wants the right technology at the right time and at the right price. This should be in line with a realistic view of the services evolution and future bandwidth demands. The need for fibre-to-the-most economical point implies the coexistence and use of different and hybrid fibre technologies.

Independent of the technology choice, technology continuity should be guaranteed to avoid future interoperability issues, the need for truck roll-outs and modifications of the outside plant infrastructure.

Question: How green is FTTH?

Independent studies show that fibre technology, in comparison with legacy systems, significantly reduces the amount of carbon dioxide which is produced by communication activities. Fibre optic systems can transport different types of data over one cable and one network, thus eliminating the need for parallel infrastructures and power provisions for CATV, fixed telephony and fixed line Internet. Furthermore, fibre optic systems can transport data over much greater systems at lower power utilization rate.

Additional questions:

Question: How can technology continuity be assured?

Question: How can truck roll be minimised?

Question: How can interoperability, standardization and end-to-end testing be embedded?

Step 4: Enable services directly to end-customer (retail?)

If the intention is to become involved in the retail market, then potential subscribers need to be convinced and choose this system. Additional questions:

Question: Why choose FTTH?

What is the best application for FTTH in the residential environment? Video? In what form? What is assured is that any offering, providing faster access and delivering an enriched experience, is certainly a good candidate for sales. FTTH is perfectly aligned to provide this.

FTTH brings unprecedented reliability and guaranteed bandwidth to the home, ensuring a more personalized touch for all.

FTTH brings a richer service offering to the connected home, in a multi-room and multi-screen approach. This will increase the demand for service assurance and remote management solutions for in-home devices and services.

Question: How to move end-users from legacy to enhanced services?

End-users need the visual richness offered by FTTH based access. Adding a visual component to legacy communication services (e.g. video telephony) and to future communication and entertainment services (e.g. immersive communication) is considered one of the key elements for creating an enhanced end-user experience.

Furthermore, policy makers consider FTTH a motor for socio-economic development as well as providing the opportunity to introduce services such as e-health, e-learning, e-government to citizens. Providing services relevant to personal lifestyle and bringing added value to society will further accelerate the mass market acceptance of FTTH.

Additional questions:

Question: How to market the enhanced value offered by FTTH?

Question: What service definitions and assurance procedures should be put in place?

Question: What is the target audience?

Step 5: Enable service models with third parties (wholesale?)

It is not a requirement to implement the entire “vertically integrated” model and enter the retail market alone. Partnerships, agreements, working cooperations etc. can all be incorporated to bring about successful FTTH systems. Additional questions:

Question: How to attract Application, Content and Service Providers?

To build a sustainable business model for FTTH, it is necessary to attract innovative third-party application, content and service providers. This requires dedicated service delivery platforms. Essentially, these

platforms, based upon open APIs, hide the complexity of the underlying infrastructure and facilitate a more rapid and transparent service delivery.

Exposure of network capacity in a managed, quality-controlled manner is of special interest to trusted parties such as businesses, energy providers and (semi-) public organizations; these groups are willing to pay a premium for this service.

Following on from a guaranteed bandwidth and QoS, the Service Level Agreement (SLA) may cover a wide range of managed common services such as, hosting facilities, app stores, application life cycle management etc. This approach may attract new market entrants, lacking the scale and expertise, but enriching the FTTH ecosystem with innovative applications, services and content.

Question: How to expand beyond traditional triple play offerings?

Moving beyond the traditional commercial triple play offering requires partnerships between Network Service Providers (NSP), Consumer Electronic (CE) manufacturers and Application & Content Providers (ACP). For example, innovative business models are needed for Over-The-Top video delivery to coexist with managed IPTV services.

Additional questions:

Question: How to build a business case for service providers?

Question: How to manage multiple service providers (Quality of Service, Bandwidth, etc)?

Question: What role does advertising have in these business models?

More information relating to the deployment and operation of FTTH is available in the FTTH Handbook.



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