NEXT GENERATION ACCESS NETWORKS AND MARKET STRUCTURE

[DSTI/ICCP/CISP(2010)5/FINAL]

OECD HIGH LEVEL MEETING

THE INTERNET ECONOMY: GENERATING INNOVATION AND GROWTH

28-29 JUNE 2011, OECD CONFERENCE CENTRE, PARIS

FOREWORD

The Working Party on Communication Infrastructures and Services Policy discussed this paper at its meeting in December 2010. The Working Party agreed to recommend the paper for declassification to the Committee for Information, Computer and Communications Policy (ICCP). The ICCP Committee agreed to the declassification of the paper in March 2011.

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MAIN POINTS

This report focuses on developments in broadband market structures emerging from the deployment of high-speed broadband services and the policy and regulatory implications. The aim is to underline good practices for policy and regulation in relation to “next generation access networks” (NGA[1]) and the market structures to enhance their development. The report builds on earlier OECD work, which examined developments in fibre technology on investment and work on structural separation. This was developed as input into the OECD’s Seoul Ministerial on *The Future of the Internet Economy*. This included OECD Policy Guidance on Convergence and Next Generation Networks.

The report conducts a ‘stock take’ of important changes taking place in communication access networks with the deployment of fibre in the “local loop”. These developments have led to concerns with respect to the continued development of competition. In particular, the costs of deployment have led many analysts to question whether the market can sustain more than two providers in dense urban areas and perhaps only a single provider in more sparsely populated areas. Second, the difficulty for third parties to get access to fibre loops depends on the topology used by incumbents, or first movers, in their build out. In turn, this has raised questions with respect to market structures for competition and whether some form of separation should be required between NGA networks and the provision of services.

With the increasing use of fibre and the desire to expand the availability of improved broadband, network reach and capabilities, policy makers and regulators are seeking to ensure efficient investment, innovation and consumer choice. Following the liberalisation of communication markets, competition has been a critical tool in meeting these objectives. The challenge is how to ensure these benefits that flow from competition will be retained and enhanced in the new environment. Recently, there have been a number of different approaches taken by OECD countries in respect to NGA market structure. These include some adopting functional or structural separation; some seeking to enhance intermodal competition; some using public funding to influence or determine market structure; and all considering the future role of regulatory tools used with previous networks. Up to now, whenever there has been judged to be insufficient competition, tools such as unbundling or even separating carriage from services (*e.g.* splitting basic telecommunication provision from so called enhanced services) have in some cases been applied.

The approach to market structure, as documented in this report, is being strongly influenced by the starting point of different OECD countries. Some have independently owned cross-platform competition, between the first generation of fixed broadband networks, and aim to increase competition using future wireless broadband. Yet, even in these countries there may, at best, be a single NGA in some areas. The objective of this report is not to be prescriptive in terms of which technology and market structure is best placed to deliver competitive higher speed broadband services. In many countries, it is unlikely to be economically feasible to build out Fibre-to-the Home (FTTH) or, sometimes, other high-speed technologies, throughout a country even if public investment is utilised. Given this, policy makers need to give careful consideration to alternative technologies with a lower incremental cost of deployment. In countries with widespread geographical coverage of cable networks, one option could be upgrading this infrastructure with DOCSIS 3.0. but also various wireless technologies may be considered to extend coverage.

Clearly an assessment of the level of competition (including market structures), which is likely to emerge as fibre local loops are developed, needs to be made in each country. This is because, as highlighted in this report, the economics of fibre investment in local access are such that it may be difficult to ensure facilities-based competition across all geographic regions in a country. This may call for policy action to help ensure access to high-speed networks at competitive prices. A number of options are available each with strengths and weaknesses. One option, which is gaining support in some countries, is the structural separation of the network from the provision of services, which will likely enhance retail competition, but may also result in a wholesale monopoly. In some countries functional separation is being utilised with similar goals and potential outcomes. A further option is to apply other forms of regulation (such as some network neutrality requirements) that give more freedom for market forces to develop in what is a new and rapidly changing environment.

In addition, given that there is a high probability that public funding will be needed to construct high-speed broadband networks in a number of geographic areas, this will also have a profound effect on how a market structure will evolve in those areas. This is why choices on market structures, and principles or good practices, in relation to which market structure is chosen to enhance competition, or ensure regulatory safeguards where there is insufficient competition, are essential. In this context there are a number of issues that policy makers and regulators need to consider:

- Any full national rollout of NGAs is likely to require government support. In particular in rural and remote areas. In other areas, with the exception of dense urban areas, replicating networks may be difficult with consequent implications for competition.
- The nature and extent of economies of scale and scope in NGA investment are likely to have significant implications for the market structure and, in turn, impact on how the market needs to be regulated.
- Regulatory measures may involve a mixture of structural and behavioural interventions mandating access to non-replicable assets and encouraging entry into competitive activities. The objective of such access measures, including bitstream, is to confer benefits to consumers, through lower prices, improved speeds and quality-of-service, innovative health and education products, specialized entertainment or business services and so forth. This would also serve to increase next generation broadband service take-up. Some operators, such as new market entrants, need various access products to compete in a NGA environment, including backhaul, if these facilities cannot be economically replicated. For instance, for FTTH these may consist of access to civil engineering infrastructure, to the terminating segment, to the unbundled fibre loop or of wholesale broadband access as circumstances dictate.
- The high costs of rollout of NGA networks are to a large extent dependent on civil engineering costs. In order to facilitate competing fibre local loops, reduce costs and reduce multiple excavation and other civil works in municipalities, the sharing of existing ducts of telecommunications and cable companies, but also those of other utilities, can be an important policy requirement.
- Access to buildings and sharing of in-house wiring can be important to ensure effective competition. Where this is so, measures for facilitating the sharing of inside wiring among operators in multiple-dwelling units should be adopted.
- Functional and structural separation could provide an environment for services innovation in both retail communication services and in underpinning innovation in the broader economy and society.

The policy challenge is how to provide a set of incentives for efficient infrastructure innovation and to make the infrastructure provider responsive to service providers.

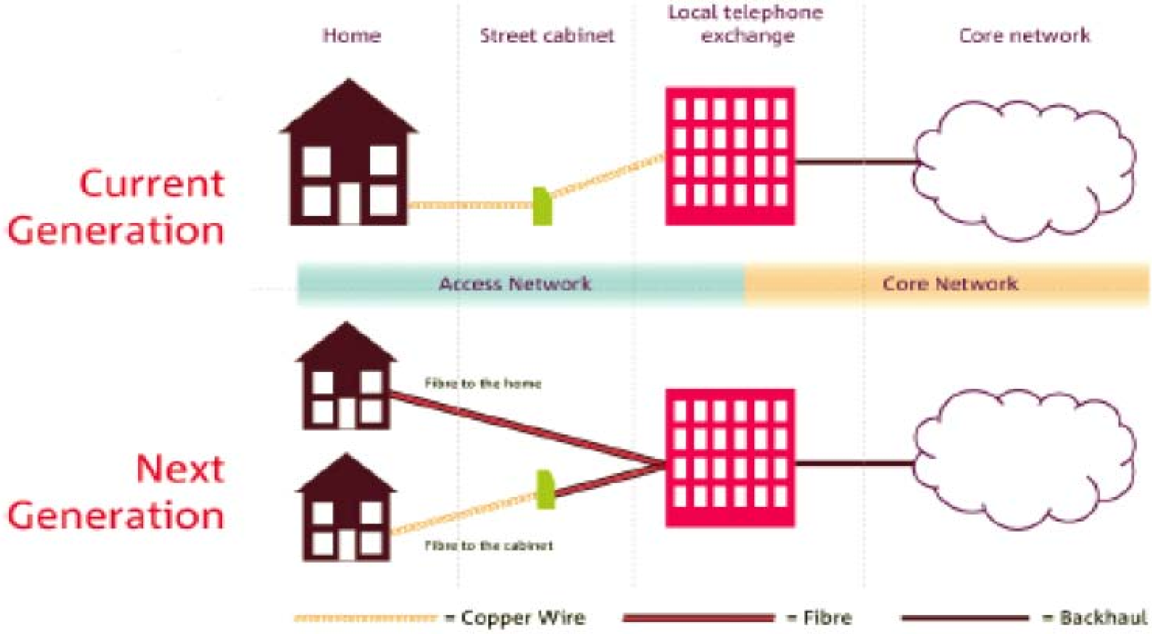
- Although fibre technologies seem to be future-proof, care should be taken not to fall into the same trap as occurred during the PSTN era (traditional telephony), where arguments were made that the market was a natural monopoly justifying existing market structures with either state-owned or private monopolies, and where service innovation was slow. Where there is structural separation, the operator of the NGA needs to have adequate incentives to upgrade networks.
- National policies for broadband networks should go hand in hand with demand side policies to develop smart electricity grids, health, school and transportation applications in order to enhance investment incentives and, at the same time, maximise the economic and social impact of NGAs.
- Where functional or structural separation is chosen as a policy option, policy should continue to allow market contestability by ensuring that no technology is precluded from entry, including entry of fixed wireless, satellite, mobile, cable and any other technology that can (in future) prove suitable. Wherever possible, barriers to entry (and exit) should be minimised.
- Policies on "traffic prioritisation" become increasingly significant where the number of networks, and thus the number of access providers, is limited. These policies should seek to ensure that access providers do not discriminate against third-party service providers that compete against the access providers' own services or otherwise discriminate among service providers in the provision of "like" services.
- In view of the limited potential for replication of NGA, bitstream or other forms of network access may be an important element of regulatory strategy in a Fibre to the Building (FTTB)/FTTH environment.

SECTION 1. INTRODUCTION

1.1 Introduction

In the last few years attention has turned to the developments in so-called next generation telecommunication networks[1]. These next generation networks (NGNs) include two elements: the Next Generation Core and the Next Generation Access (Figure 1.1). The Next Generation Core refers to the core IP network and is characterised by replacement of legacy transmission and switching equipment with IP technology in the core, or backbone network. It allows for simpler, less costly and straightforward networks that are used to deliver all services. High speed broadband refers to the access technology (optical fibre, copper or wireless) and its deployment in the local loop[2], either to a street cabinet close to customer premises in conjunction with xDSL, or deployment of fibre or wireless to the customer premises. It is typically characterised by significantly higher broadband speeds than those currently widely available, better quality of service and greater symmetry. The term next generation access (NGA) is commonly used to describe the requirement of fibre coming closer to the end-user, or providing the direct connection. As a result, the copper or cable wire is to a larger extent or fully replaced with fibre-optic technology. Wireless technologies can also be considered as NGAs. Indeed, wireless can provide a vital option to extend and improve broadband coverage. This paper, however, focuses on issues associated with wired networks, as for the most part wireless networks are complementary and do not provide full substitution to wired facilities in all cases.

Figure 1.1: Next generation access networks



Source: Ofcom (2010b).

The developments in NGA have led to concerns with respect to the continued development of competition, for a number of reasons. In particular, the costs of deployment have led many analysts to question whether the market can sustain more than two providers in dense urban areas and perhaps only a single provider in more sparsely populated areas. Secondly, the difficulty for third parties to get access to fibre loops depending on the topology used by incumbents in their build out. In turn, this has raised questions with respect to market structure for competition and, in particular, led many to question whether some form of separation should be required between the operation of NGA access networks and the provision of services.[3]

Issues surrounding market structure, for the provision of telecommunication services, are receiving as much attention today as they did during the initial introduction of competition over two decades ago. It is not that market liberalisation has failed to produce considerable increases in the efficiency of communication markets. It has been extremely successful across the OECD area. Rather, as when competition was first introduced to telecommunication markets, the debate among stakeholders is how to structure competitive market delivery in view of technological and service changes. For example, should the primary emphasis be placed on end-to-end infrastructure competition in tandem with the provision of seamless services? Alternatively, by way of a further example, should wholesale infrastructure and retail services be separated, as has happened in some other network industries, such as energy and transport?

All OECD governments support infrastructure competition and the debate is largely about NGA. The focus is on how to facilitate fixed line broadband network connectivity to small business and households, especially those in suburban, rural and remote areas where there may be insufficient competition. In most OECD countries competitive backbone infrastructure, between cities and large population centres, has been established, along with healthy levels of competition in central business districts. In rural areas there may be, however, less backbone competition and some governments have chosen to publicly fund "open access" broadband networks (*e.g.* Chile).

There may be little competition, in some areas, for local access to end users and the back-haul from these competitive local access facilities to reach backbone networks. Alternative platforms, such as wireless networks and cable, are a key component in the debate, from the perspective of the degree to which they can provide competitive services. All agree that wireless networks are at least complementary and can provide substitution for some traditional telecommunication services as well as some new services. They are clearly valued by users both in terms of services for which they can provide substitution and for those for which they have the inherent benefits of mobility. What is less clear is whether they are sufficiently close substitutes, in terms of competition, to constrain the price of services provided over fixed-line NGAs.

The speeds of wireless networks are steadily increasing, but are also increasing for fixed fibre networks so that it is unlikely that there will be convergence in terms of speeds between fixed and wireless networks. Performance in wireless networks is related to a number of factors such as the number of users concurrently utilising service, distance to the tower and so forth. The immense popularity of smart phones, including applications that automatically update data services, has placed strains on some wireless networks. All broadband services, including those on fixed networks, to a greater or lesser extent share the characteristic of capacity constraint impacted by user numbers. In the case of mobile, the impacts on capacity are typically more pronounced due to capacity and spectrum scarcity.

Governments wanting to increase infrastructure competition with incumbents, through platforms such as fixed wireless, have long recognised that 'backhaul' has been one of the major challenges to small or localised new entrants. While many mobile wireless operators would not be considered small or localised, they also rely heavily on fixed networks to provide transmission to backbone networks. In other words, fixed networks, for a variety of reasons, are essential for the goals policy makers have for broadband wireless services.

More recently, a further consideration has been direct government investment in broadband infrastructure. In some countries, this has been in part a stimulus measure to counteract the effects of the global financial crisis. In others, the driver has been a desire to see NGA development occur faster than they consider the market would otherwise deliver the service or to areas they believe the market will not reach, such as rural areas. In these instances, governments have had to consider how this action would impact on existing market structure. Policy makers do not wish to reinforce market power nor do they wish to fund duplicate infrastructure. They would prefer to involve the private sector, as they do not want to return to the days when they had ongoing ownership and management of infrastructure and services. Although regulation can make these available to new entrants, new infrastructure construction will be less expensive if it can leverage existing facilities, such as cable ducts or poles.

Capital markets apply the same criteria for investment across the economy. Fundamentally, they look at the risk and reward from NGA investment. Market structure and its associated regulation is a key component of this equation. Accordingly, market structure and the type of regulatory approach it may dictate will strongly influence investment. Capital markets' willingness to finance investments at given terms depends on the risks and rewards associated with the investment. Lower risks imply lower interest rates all else being equal. Consequently, regulatory decisions must be made taking into account implications for investment. Investors may see a place for long-term stable returns with low risk from investment in utilities, such as may be the case with separate provision of infrastructure and services. Such a separation would entail high levels of regulation for the infrastructure component where the barriers to market entry are high. In more contestable markets, investors expect higher rates of return from firms with seamless provision of infrastructure and service.

Governments can take a longer-term and broader view of investment returns than the private sector. Some governments appear to have concluded that capital markets will not provide enough investment to the private sector to build NGAs, within the time scale, capability and coverage, which meet their policy objectives. Accordingly, some governments propose direct public investment in NGAs or redirecting existing internal telecommunication subsidies stemming from charges to users. This is either because of the desire to stimulate development, during the global financial crisis, or connect those potential end-users analysis has indicated are not likely to be served by private investment-driven deployment. In addition, there may be positive externalities which arise from NGAs that are not taken into account by private investors in investment decisions.[4] It may also be the case that some believe investors prefer firms to "harvest" existing infrastructure rather than build NGAs, though different markets have had different experiences to date. In the United States, for example, Verizon plans to pass roughly 18 million premises with FTTH. This alone would contradict the notion that there is any hard and fast rule on "harvesting" existing infrastructure rather than deploying NGA.

There are a number of approaches being adopted by OECD governments. In the longer term, many policy makers are concerned that the economics of NGA and market forces will tend towards there being only one, or at best two, fixed broadband access networks that can be regarded as fully substitutable in terms of delivering competitive choices for customers. In addition, regulators are concerned that firms that control bottleneck infrastructure will seek to exploit this advantage in competing with other firms. This is why some countries have introduced accounting separation (*i.e.* an operator creates separate cost centres under an integrated management and ownership structure); operational separation (*i.e,* where an operator with significant market power is required to maintain separate wholesale and retail business units)[5] *e.g.,* Italy; functional separation (*i.e.* an operator creates independent entities that perform discrete functions but retains common ownership) *e.g.* Sweden, United Kingdom; while more recently, others are introducing models which include vertical structural separation (*i.e,* independent ownership of entities each separately providing infrastructure and services[6]) *e.g.* Australia, New Zealand and Singapore.

One advantage approaches such as functional separation in combination with local loop unbundling have been considered to have in the past over structural separation is that they were assessed to be more compatible with infrastructure competition. Policy makers functionally separating a telecommunication network provider aimed to encourage other providers to enter the market through access to "equivalent inputs" and, as they developed their business, to invest in alternative facilities. By way of contrast, a vertical structural separation, in other words splitting up the ownership of entities providing wholesale (infrastructure) and retail (services), may have limited the development of competitive infrastructure. This is one reason, among several, why OECD countries have not favoured vertical separation in the past.

Proponents of structural separation say that it may involve less complex oversight than functional separation. They note that vertical separation of infrastructure and services would enable the market to provide effective discipline, in areas such as pricing of services, as well as stimulating the innovation users have come to expect from service competition. On the other hand, the strengths of such a split for services may become drawbacks for infrastructure provision where market forces may not result in competition as they have done in past years. Perhaps the main difference for NGA, as opposed to the first generation of broadband provision, is that the regulator may receive less assistance from infrastructure competition. In other words, in terms of first generation broadband, policy makers could apply the combination of regulatory intervention and competition from alternative facilities.

While voluntary vertical separation has, at times, been mooted by the private sector (usually investment companies) there are few actual examples of this being carried out among incumbents. A split between wholesale and retail is slightly more common with new entrants (*e.g.* municipal networks or the model proposed by "Lightsquared" for a broadband wireless network in the United States). Incumbents that have functionally separated have usually done so based on potential "carrots and sticks". A potential carrot may be the ability to tender for a project only available to entities with a wholesale and retail separation. A potential consideration for voluntary functional separation may be the prospect of being subjected to a stronger regulatory remedy such as structural separation.

There are widely differing opinions with respect to functional separation and what it means for investment. Some believe it will provide less incentive for private investment in NGA and would penalise those firms that have already invested. Others, while perhaps not always welcoming functional separation, prefer it to structural separation. These views may be shaped by their assessment of the likelihood of competition for NGA access. Those arguing for seamless infrastructure and services competition, propose an optimistic scenario for alternative platforms. In their view, the market will provide sufficient competition to keep entities, otherwise developing market power, in check. Another view is that if NGA access is likely to be provided by a single network, and that governments will take action to curtail this monopoly power (or duopoly power in the case of two NGAs), they would prefer this to be through functional rather than structural separation. In part, this is because the latter removes the ability of firms to leverage returns from both infrastructure and services to attract capital.

Technological and investment choices and market structure

A question in considering NGA development and future market structures is the broad direction of technology and the choices being made by "first movers". One potential market outcome, in many OECD countries, is that some business premises or households may only be served by a single NGA or by just two NGAs. Should this situation eventuate and policy makers decide to use certain regulatory tools, such as "unbundling of local loops", it is an open question as to whether choices made by the initial providers allow this option to be made available.

In regard to fibre optic cables connecting households, there are two leading choices in terms of the topology of networks. This can be summarised as follows. One choice is to build what are called “point-to-point” networks which extend a dedicated fibre optic cable to each home from an aggregated exchange point. The other option is to build “point-to-multipoint” networks, commonly used by deep-fibre VDSL, cable and fibre Passive Optical Network (PON)-based technologies.[7] A point-to-multipoint topology shares the capacity of one fibre line among multiple households. Proponents of both topologies cite a number of advantages and drawbacks for PON and point-to-point networks. Those favouring PON networks, for example, say they are less expensive to deploy and that the shared capacity will be sufficient for the future. They also say that service competition, in areas with lower population density, is more likely to be delivered by a PON than a point-to-point network. This is because smaller operators are more likely to offer their service over a bitstream model rather than building their networks out to local access points in these areas. Supporters of point-to-point networks counter that they are more flexible and, therefore, are more able to future-proof technological choices taken today. This latter factor is an important consideration for governments for a number of reasons.

If, as some argue, point-to-multipoint networks are less flexible in enabling certain regulatory tools to be applied, this may limit the choice of policy makers in the future. In the case of a government deciding one or two NGA connections provide insufficient competition, they may decide to mandate unbundling of local loops. If the initial choice was to use point-to-multipoint this may be less practical or more expensive than if the choice had been for a point-to-point NGA. In the absence of an option to apply unbundling, policy makers may need to look to options such as multi-fibre provision, enhanced bitstream access and functional or structural separation they may not have preferred had unbundling been available. Even with separation, the separated entity may be limited in the types of wholesale access it could provide under a point-to-multipoint topology.

A further factor that needs to be considered in terms of market structure is the impact of convergence of communication networks and services on demand and revenue. Revenue streams from previously distinct industries financed much of the first generation of broadband infrastructure. Telephony financed the development of the PSTN while television underpinned cable networks. Both telecommunication and cable companies now offer each other services along with new services such as Internet access. But these revenue streams, particularly among traditional services, also face competition from other platforms and services. As all these entities upgraded networks or provided competition over networks owned by rivals, policy makers took advantage of this to encourage infrastructure competition. Certainly, the revenue streams from which incumbents in both telecommunication and cable started could be ploughed back into infrastructure development. Today, however, competition has placed greater discipline on the pricing of traditional services and neither incumbent has some of the advantages they once had over the other (*e.g.* telephone services). This raises the question of whether capital markets will support the development of competition in NGA provision, particularly if they will be limited to utility-like returns.

Choices made on the basis of upgrading existing infrastructure at marginal cost and to protect monopoly rents stemming from earlier investments may produce a fundamentally different result for NGA. It is not clear, for example, that a second NGA, whether an upgraded DSL or cable network, will be deployed if an existing one is already available in a suburban street. In short, the development of fixed fibre optic access networks will likely see the traditional differences between service providers disappear from the market. Certainly, the economics which encouraged competition from previously separated vantage points, which proved to be viable, is now an open question in terms of fibre optic networks. If a second NGA in areas with relatively low population densities is to be economically viable, this will probably not be as a result of any technological limitation of an existing fibre network.

It is perilous to argue that a market is a natural monopoly due to the characteristics of a certain technology. Prior to the introduction of competition, some economists argued that telecommunication networks were a natural monopoly with some of their arguments rooted in technology. They did not, however, give due recognition to technological change and the inefficiencies of monopolies and this will be a key challenge in the regulation of any monopoly or duopoly NGA infrastructure provider(s). Many doubt that a limited number of local access infrastructure providers will provide an environment conducive to innovation without strong services competition.

Functional and structural separation, some argue, would provide the right environment for services innovation in both retail communication services and in underpinning innovation in the broader economy and society. This may well be the case, but the challenge faced by policy makers is how to provide the right set of incentives for infrastructure innovation and to make providers responsive to service providers. Removing incentives to act against other firms is not the same thing as providing incentives to act in an efficient manner to support those same firms.

An end-to-end infrastructure provider that is not separated from services but with a virtual monopoly over a NGA is unlikely to have strong incentives to promote innovation in its own network or more broadly for adjacent competitors. This could be the case, if the wholesale price for NGA access was to be too low to create adequate investment incentives. Accordingly, governments will need to return to the question of how to sustain competition or how to regulate if there is a single NGA provider to homes or business. It is important to underline here that no one believes there will not be choices, such as via wireless or cable, for some services. Yet, even here, a single NGA provider may have significant advantages over rivals in terms of bundling services or favouring their own services. This could be the case to the extent that vertical economies of scope are foregone.

1.2 Structure of this report

Following this introduction, Section 2 discusses some aspects of the technology for provision of high-speed broadband access. This is because, for instance, the degree of access substitutability of alternative available technologies (*e.g.*, fibre, cable, fixed wireless) influences market definition and market characteristics crucial to analysis of market structure and access conditions/prospects. Then, Section 3 examines the economics of NGA deployment and implications for market structure. It concludes that for fibre networks, it is likely that only one access provider, or at most two, will operate. This has stimulated increasing debate over the need for functional separation and, indeed, structural separation. This debate is the focus of Section 4. Section 5 examines the various approaches that have been adopted, thus far, by OECD countries in response to such emerging concerns over NGA market structure and competition. An attempt is made to classify the approaches taken into a number of categories. A clear conclusion is that a single approach is yet to emerge but that policy makers can learn much from the experience of other countries in relation to their starting point. Market contestability should be promoted to increase competition.

A separate Annex to the report contains selected country descriptions and background information drawn on for this report (DSTI/ICCP/CISP(2010)5/ANN1/FINAL).

SECTION 2. NGA TECHNOLOGY AND ACCESS REGULATION IN A NGA ENVIRONMENT

The degree of access/service substitutability presented by alternative technologies influences market definition and market characteristics crucial to analysis of market structure. These issues are addressed in detail in, for example, Ofcom's "Review of the wholesale local access market" (Ofcom, 2010c).

The discussion in this section is intended to provide some general appreciation of these technology issues that impact on market characteristics. In addition it provides a 'flavour' of the debate between advocates of fixed line technologies versus fixed and mobile wireless; and the ongoing debate between supporters of different fixed line technologies such as Fibre-to-the-Curb/very fast DSL (FTTC/VDSL) and point-to-point and PON-based point-to-multipoint FTTH.

The implications of these issues for NGA access regulation are highlighted. Importantly, the discussion also reiterates the need to continue to be guided by the principles of contestable markets and technological neutrality.

2.1. NGA technology

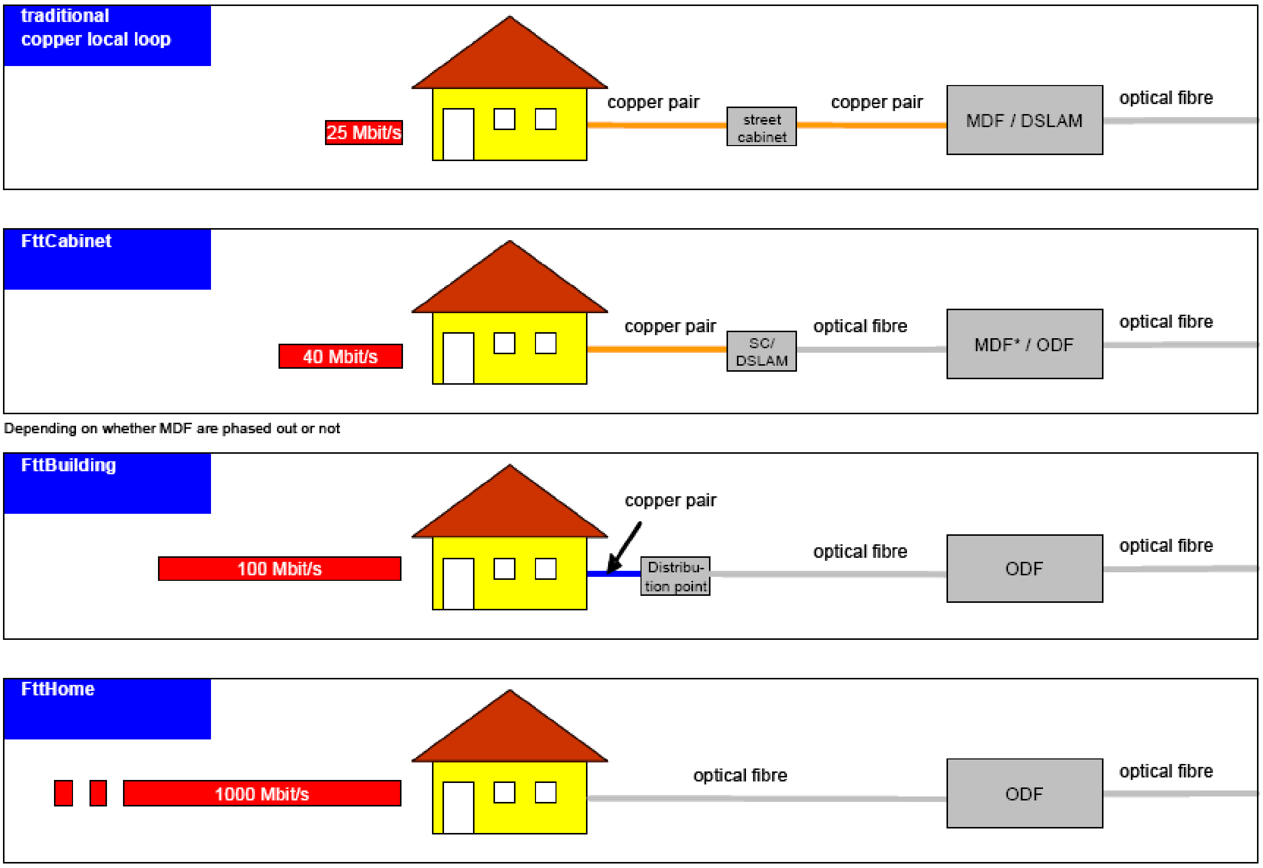
NGAs are new or upgraded infrastructure that will allow substantial improvements in broadband speeds and quality of service compared with current services. A typical advertised broadband offer, using xDSL for example, might be up to 12 Mbit/s to 24 Mbit/s although actual throughput may not reach these speeds. By way of contrast, a typical fibre offer may be 100 Mbit/s, with some commercial services now offered at 1 Gbit/s, for residential users. Although it is most often used to refer to networks using fibre optic technology, policy makers and regulators see critical roles for other technologies including cable, fixed wireless and mobile. When such technologies are included, the networks are often referred to as high-speed or ultra-fast broadband networks.[8]

There are two main types of fibre-based access: FTTC and FTTH (Figure 2.1). FTTC is an access network structure in which optical fibre extends from the exchange to a cabinet, usually located up to a few hundred metres from the subscriber's premises. The remaining part of the access network from the cabinet to the customer is usually copper wire, but could be based on another technology, such as wireless. FTTC deployment may either use VDSL (very fast DSL) technology or DOCSIS 3.0 cable technology over the connection (copper- or cable-based) that remains between the cabinet and the customer. Such an access infrastructure, depending on the distance from the cabinet to the customer premise, in combination with VDSL or DOCSIS 3.0, may allow bandwidth offers to be increased, from say 24 Mbit/s to 50 Mbit/s (using VDSL2 or DOCSIS 3.0). Like ADSL2+, this allows its use for some services requiring higher levels of bandwidth, though upstream performance may be more limited than downstream, and distance will limit bandwidth for householders more than a few hundred metres from a cabinet.

To achieve shorter loops, as depicted in Figure 2.1, VDSL-access lines between end-user locations and DSLAMs[9] need to be deployed. Therefore, the DSLAM is shifted from the MDF[10] to the street cabinet as an Outdoor-DSLAM and the local loop dedicated to the end-user ends at the cabinet. Aggregated traffic from all the end-users connected to the DSLAM is transported via a new optic fibre link between the cabinet and the ODF[11] thus shifting the fibre based backhaul network to the cabinet closer to a customer. Consequently, the former telecommunications exchanges may be phased out as fibre connection is made to connection cabinets and such phasing out of telecommunications exchanges will affect co-located operators. For instance, as part of using VDSL technology, KPN in the Netherlands has announced the phasing out of the majority of its telecommunication exchanges.

There are different views regarding the cost effectiveness of investing in VDSL (FTTC). This technology provides significantly higher capacity than current ADSL technologies, and allows relatively quick deployment at a lower cost compared to FTTH networks. Others prefer to deploy directly FTTH networks, considering their higher performance and scalability, and therefore their capability to meet future bandwidth demand. FTTH is a fully optical solution going to the end-user's home/premises. FTTB is frequently included in the FTTH scenario. FTTH deployment now passes 20 million homes with almost 6.5 million households signing up for FTTH connections.[12]

Figure 2.1 Illustration of scenarios for the rollout of fibre



Source: ERG (2007).

Fibre to the home (FTTH) or FTTC?

Analysys Mason, a consulting firm, has recently argued that network operators should reconsider FTTC/VDSL, because there has not been enough service and device innovation yet to warrant the expense of FTTH. However, some private carriers have made purely commercial decisions to deploy FTTH, in some cases despite the existence of alternative high speed broadband networks. This has fed into the debate over which technology is suitable for NGA.[13] Box 2.1 provides an elaboration and 'flavour' of this debate in the industry.

The reason for highlighting the debate over technology here is to reiterate that in this area, policy makers and regulators should be wary of shifting from a technology-neutral stance. Unless there are persuasive reasons for placing to one side this principle, it seems sensible to allow operators to make their decisions based on commercial criteria and strategies. For operators like KPN, the debate is not just an academic one as Box 2.2 indicates. Nevertheless, where public funding is involved, policy makers may have to make a choice, such as for publicly owned entities or infrastructure supported with public investment, based on the recommendations of the network operator. In addition, they need to assess the implications for competition as decisions are taken by commercial players.

Box 2.1. Very fast VDSL vectoring and virtual unbundling: the next superfast broadband compromise

…many incumbents have chosen to replace the copper between the local telephone exchange and street cabinet with fibre while upgrading the final few hundred metres of copper to support VDSL (very fast DSL). This is considered a much cheaper and faster way to offer superfast speeds than laying fibre direct to the home or building (FTTH/B). But some policymakers accuse the incumbents of being shortsighted. VDSL cannot support the speeds their nations will need to compete even in the medium term, which might run to hundreds, rather than tens, of megabits per second. Only FTTH/B connections will prove future-proof enough, they say, and countries such as the United States, Japan and Korea already have them. Policymakers also have a problem with the challenges VDSL networks pose to competition. Many alternative operators compete via price and new features by installing their own equipment on incumbents' DSL networks through local-loop unbundling. Networks based on a point-to-point FTTH/B architecture offer a similar opportunity but are generally held by incumbents to cost an order of magnitude more to roll out than ones based on fiber-to-the-cabinet and VDSL. Their technology of choice can in theory be unbundled, but in reality few alternative operators might be able to afford to do so.

Ultimately, policymakers have had to compromise. Politicians have accepted that pressuring incumbents to commit to a more expensive technology could discourage them from investing in NGA at all, while regulators have devised ways around the unbundling problem. But vendors have been lab testing an array of technologies that promise to enable operators to offer FTTH/B-like speeds over their VDSL networks, using techniques known as vectoring, line bonding and phantom mode[14]. And industry sources suggest that operators are coming close to achieving such gains in field trials. Although all three techniques can be used in combination, vectoring holds the most promise for boosting superfast speeds in the residential market. But if regulators allow the use of vectoring, they must also accept another compromise. Vectoring requires an operator to be in full control of the group, or "binder", of lines it wants to affect. If another operator has unbundled one or more lines in that binder, vectoring the rest will not produce meaningful gains in speeds, vendors say. This presents a dilemma to policymakers. Although it might be impractical to unbundle a standard FTTC/VDSL network, it is not impossible. Regulators can still oblige incumbents to offer the option, should any alternative operator want it. But such rules could discourage an incumbent from investing in vectoring, preventing consumers from accessing the higher speeds the technology promises.

One option for regulators is to promote "virtual unbundling." This approach, pioneered by the United Kingdom's Ofcom and BT's Openreach network division, is intended to offer alternative operators most of the features unbundling does, without the need to install their own equipment on the incumbent's network. In theory, this could enable the incumbent and alternative operators to offer vectored services over lines in the same binder…
In June, the European Commission issued statements accepting proposals by the United Kingdom's and Austria's regulators to oblige their incumbents to offer virtual unbundling of their NGA networks, but insisting that they must impose full unbundling "as soon as technically and economically possible." In the meantime, policymakers should consider how willing they are to trade competition for NGA networks. Today's virtual unbundling services are some way from replicating all the features "real" ones offer, and questions remain about whether they will allow alternative operators enough flexibility to compete on price.

Source: A shortened version of Gallagher, R (2010), "Very fast VDSL, vectoring and virtual unbundling: the next superfast broadband compromise?" Telecom.com, 19 July. Available at: www.telecoms.com/21618/very-fast-vdsl-vectoring-and-virtual-unbundling-the-next-superfast-broadband-compromise/

Box 2.2. Should KPN push ahead with FTTH or switch to VDSL?

KPN has announced that it would stop the further roll-out of VDSL to SDF locations (street cabinets). This suggests it's abandoning FTTC. The Dutch operator will continue with the roll-out of VDSL to MDF sites (central offices), also known as VDSL@CO. In addition to ADSL, which will continue to operate for some years, KPN is developing FTTH, which is being rolled out by its partner Reggefiber. KPN's choice for VDSL@CO is completely logical. It is a relatively cheap way to further exploit existing assets (MDF sites with fibre backhaul). In contrast, FTTC is costly due to the need to take fibre to 20,000 street cabinets. It's also no interim strategy to FTTH, as the Reggefiber network architecture is completely different and cannot elaborate on FTTC. That is KPN's story. ….there is another factor at play – something that's not relevant in every country, but is in the Netherlands: a cable network with nationwide coverage. As noted above, VDSL@CO is the more logical choice over FTTC, but even with that, less than half of the population of the Netherlands will be reached. Furthermore, the speeds are less than those of cable broadband. DSL providers are increasingly losing subscribers to cable and FTTH. In other words, the presence of cable makes the roll-out of FTTH a sound, logical choice for KPN.

Source: Poulus, T (2010), "Should KPN push ahead with FTTH or switch to VDSL?", *CET*, 10 September.

Cable television

Cable television (CATV) operators have been upgrading their infrastructure to hybrid fibre copper (HFC) allowing for bi-directional traffic and using DOCSIS 3.0 technology to increase network capacity.[15] The bandwidth provided by cable networks using DOCSIS 3.0 will allow for up to 160-240 Mbit/s downstream and 120 Mbit/s upstream for end-users. This, however, will have to be shared by end-users. There can be between 50 to 1 000 customers on a cable node who share the bandwidth on the node. Though an individual customer will not get more than 160-240 Mbit/s downstream, a cable ISP can split the subscribers in separate groups that each has access to 160-240 Mbit/s thereby lowering the contention rates.[16] The upstream, however, is shared among all customers equally and cannot be increased without upgrades to the filters in the network. While cable modem networks face similar performance challenges to DSL networks due to the shared nature of the network, they do not suffer from speed degradation due to line length. As a result, the maximum speed experienced by cable modem customers will generally match, and not fall short of, the speed advertised to them. Thus, cable modem networks may face fewer performance challenges than DSL networks.

It is notable that 29% of all 2010 broadband connections in OECD countries were provided by cable modem networks and it is the predominant technology in North Canada and the United States. In countries like Belgium and the Netherlands over 90% of households have access to cable and well over 80% subscribe to it for basic Television services. In those countries, cable and DSL are competing for customers. As mentioned in Box 2.2 cable is providing the more advanced speeds in some countries. Further, some consider that cable modem technology has very robust ability to provide next generation broadband services. They argue that there could be even higher DOCSIS 3.0 speeds to run over HFC. The shared throughput capacity of 860 MHz coaxial systems is roughly 5 Gbit/s if no television channels were broadcasted. Similarly, at the same time, CATV networks could split fibre nodes to serve fewer and fewer subscribers off each node. These arguments about cable are of special concern in other OECD markets where advanced cable modem services are well-placed to be a premier leading NGA technology.

The relevant issue for this report is the extent to which cable local access is a substitute for FTTC or FTTH. The answer would vary according to specific circumstances in a country (indeed, between sub-national regions within a country). For instance, Ofcom has decided to include cable-based local access in the local access product market definition.[17] However, the European Commission disagreed and felt it more appropriate to define the product market excluding cable-based local access.[18]

Fibre and wireless: complementary networks

The potential for wireless broadband access to deliver last mile speeds of 10-20 Mbit/s was investigated for Ofcom by Plextek.[19] They found that wireless cannot realistically compete with fibre over the whole of the last mile because spectrum constraints limit the capacity available except at very high frequencies. Wireless could, however, have a role as a feeder element in an urban next generation broadband network *e.g.* providing transmissions from the cabinet. Plextek identified point-to-point applications for which equipment already exists and that use abundant spectrum at 60, 70 or 80 GHz. The transmissions would travel from lamppost to lamppost down the road and the final distribution to the house would be made using Wi-Fi at 2.4 or 5 GHz. There could be a role for wireless as part of a NGA, but this is likely to be limited to specific locations probably in urban environments.

In rural areas wireless technologies could provide widespread broadband access. Nevertheless, there may be some regions only served by a single wireless provider, as is sometimes the case in countries with low population densities, in some regions. This currently occurs where the most widely deployed fixed wireless offers, for users that cannot access fixed broadband, frequently have far higher prices, lower speeds and usage caps than for DSL, cable or fibre networks in those countries.

Wireless networks will continue to be important, but as applications require increased bandwidth, and users wish to access greater amounts of data, they are expected to become complementary to fibre, rather than a substitute. As end-user bandwidth demand continues to grow, fibre will likely become the fixed-line network of choice.

Satellite has also been seen as a potential technology for delivering improved service availability. For instance, Lightsquared, a US-based telecommunications company, has proposed a wholesale access model using terrestrial 4G and Satellite capabilities. Lightsquared plans to use two orbiting satellites to bring high-speed Internet service across much of the United States by 2015 by putting together a wireless network that relies on satellites and ground-based transmission facilities to provide consumers with high-speed mobile broadband access to the Internet.[20]

At this stage of technological and market development, neither satellite nor mobile network technologies appear to be capable of providing very high speed symmetrical broadband services. That said, some claim that in the future the situation may change, pointing out that the speed of wireless is increasing greatly with 4G, ‘Long Term Evolution’ (LTE) and other technologies. For instance, LTE may theoretically reach increased peak data rates of 100 Mbit/s downlink and 50 Mbit/s uplink. Supporters argue that consumers find the flexibility and portability of wireless broadband to be of great benefit and that it is the fastest growing area of the industry at the moment. An inherent problem, however, with wireless and some other technologies, is that actual speed is reduced by the number of users at any one time.

In its future planning for the Australian NGA, for example, the network operator expects some 4% of premises to be served by fixed wireless – in areas where the cost would be prohibitive to provide fibre. In this instance the aim is to provide peak download speeds of at least 12 Mbit/s. This would be a significant advance on current capabilities though by necessity significantly different from the 100 Mbit/s, to potentially 1 Gbps, to be offered to 93% of premises in more closely settled areas. The remaining 3% of premises, in the most remote areas, would be served by satellites. Beyond these initial rollout requirements, the network operator is required to upgrade services over time.

To some extent, wireless limitations can be overcome with more transmission points in heavy traffic areas. But this will have its limits. For example, one expert estimates that a city like Melbourne with a population of 4 million would require up to 100 000 new wireless towers.[21] And that every one of those towers would need to be connected via fibre and the towers would consume 200 megawatts more electricity than a FTTH network. The expert points out that optical fibre can carry 10 000 times more information than the entire wireless spectrum used by mobile devices. Moreover, there are limitations to wireless spectrum extensions. That is why fibre has been used in backhaul and transoceanic telecommunications networks for more than 25 years.

When fibre is in place, it provides a durable and future-proof information pipe to premises that will not only enable current data rates in the range of up to 100 Mbit/s, but can be easily upgraded to 10, 100, or 1 000 times that speed. This is because associated electronics can be easily upgraded and optical fibre has a lifetime in excess of 60 years. That said, it is again noted that the changing technological circumstances makes it advisable for policy makers and regulators to maintain market contestability and technological neutrality in regard to high speed broadband technology.

2.2. Access in a NGA environment

There are a number of different network topologies for the roll-out of fibre NGA and their implications for the future development of competition, in access markets, may differ. FTTB means that fibre is laid along the entire route to the building. The fibre is normally connected to a concentration point in the building's basement, *i.e.* very close to each individual end user – normally apartment blocks. On the last stretch from the basement to each apartment, the fibre is linked together via a property network. FTTH means that fibre is laid along the entire route from the interconnection point in the local loop to the end user. In this scenario, the copper wire is completely replaced by optical fibre. This development will mean that the need for telecommunications exchanges and connection cabinets, which are used to connect the operators' networks to the local loop, will reduce in scope. Apart from a reduction in physical locations and associated costs, operators also report that FTTH-networks are cheaper to operate. For example, Verizon noted that data it gathered in the first full year of FiOS FTTH deployment (based upon a PON architecture) generated an 80% reduction in maintenance as compared to legacy copper deployed to the same area.

In regard to fibre networks, there are a number of different variants proposed in the context of next generation access networks:

- *Passive optical Networks (PON) fibre-to the-home.* PON networks differ from Point-to-Point FTTH in that they use one fibre to connect multiple end customers so that fibre is shared by users. Cheaper than point-to-point FTTH, PON central switches require more logic and encryption to integrate and separate customer streams.
- There are three successive iterations for PON standards: APON/BPON, GPON and EPON. These differ in terms of downstream/upstream speeds and their maximum reach. In those countries where LLU is mandated, the way PON networks are constructed is important from the policy and regulatory perspective since they influence the extent to which these networks can be made available to other service providers and therefore the development of competition. GPON appears to be favoured by major operators, while point-to-point is often the preferred option in municipal projects.

- *Point-to-point fibre-to-the-home/building* (point-to-point FTTH/FTTB). This is usually viewed as the most future-proof fibre network given its flexibility to handle most new bandwidth intensive applications while allowing for relatively easy upgrading of speeds. While more expensive than other alternatives, such as point-to-multipoint FTTH, some operators believe that in the longer term, point-to-point FTTH may be more cost effective. This architecture also permits full unbundling, allowing new entrants to connect at the central office (as at present with DSL technology).

As an alternative to the FTTH networks described above, some operators are investing in FTTC. FTTC increases the complexity of unbundling regulation. With fibre rolled out to the node, there is less need for local exchanges in the network since the street cabinet can function as an exchange. For alternative operators who used the unbundled local loop, the business case is often not positive since to access customers using the incumbent's loop they will need to invest up to the node. Furthermore they will possibly need to invest in a street cabinet which has power and air conditioning (creating problems at the municipal level) and it is not clear whether they can unbundle because electrical interference may prevent this. Some incumbents have indicated that they will sell their Main Distribution Frame (MDF) locations in order to finance VDSL roll-outs which could strand the investment of new entrants unless adequate regulation is put in place to ensure that new entrants are given adequate time to invest in alternatives before main distribution frames are dismantled. The viability of sub-loop unbundling has been questioned by some experts in particular because the costs involved for new entrants to roll-out their network to a street cabinet will require that they obtain a relatively high market share in the specific geographic market.

PON or a Point-to-Point architecture?

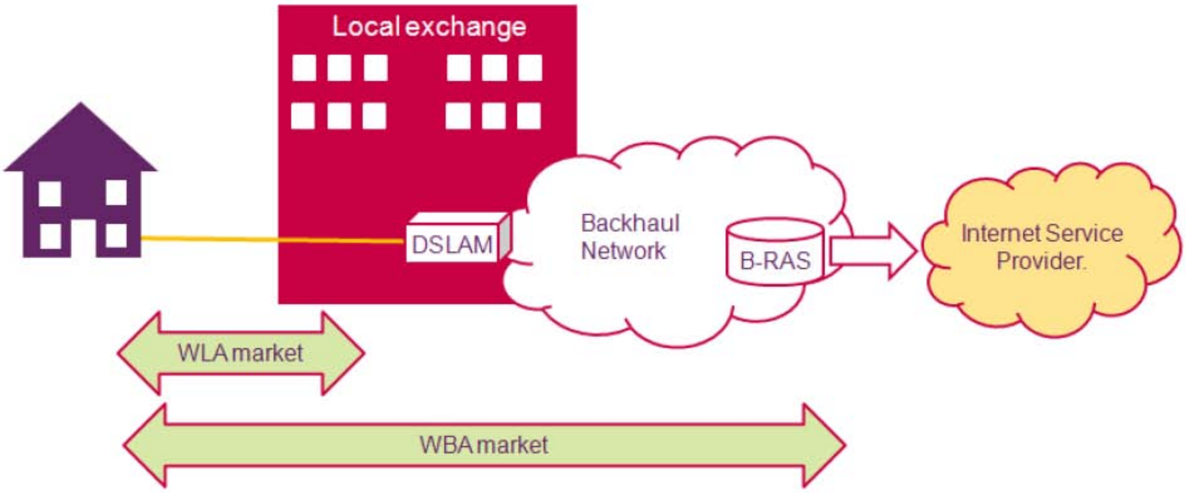
In a PON architecture, a fibre between the MPoP (metro point-of-presence)[22] and a passive optical splitter is shared between a group of (up to 64) users. From a concentration point in the field, an individual fibre is dedicated to a single customer. In a point-to-point architecture on the other hand, a separated fibre is dedicated to a single customer from the MPoP. Due to the shared fibre element, a PON architecture results in capacity constraints to the individual user, while the potential capacity of the point-to-point architecture is technically unlimited by the passive fibre network architecture and only limited by the electronics applied. The capacity limits of PON which are 2.5 Gbps (recent developments suggest up to 10Gbps based on XG-PON systems) that can be shared between up to 64 users may not be a constraining factor at present but, depending on demand growth, it may become a relevant factor in the future. In that sense a Point-to-Point architecture is a more future-proof and flexible architecture than PON.[23] Furthermore, Point-to-Point unbundling is possible. By contrast, when a PON architecture is used, a competing operator has to build out its own network up to the splitter point, while in the Point-to-Point case this network only has to reach the MPoPs. Barriers to entry for competitive operators are therefore much higher (if not prohibitively high) in a PON architecture compared to Point-to-Point. In Europe, incumbents have tended to favour PON perhaps, some suspect, to make it harder for competitors.[24]

Some argue that it will be hard to provide Unbundled Local Loop (ULL) for Point-to-Point networks as there currently is little experience with unbundling at the Optical Distribution Frame. On the other hand, Point-to-Point networks like those introduced by KPN/Reggefiber in the Netherlands were built to be open networks and facilitated multiple service providers before the regulator required unbundled access.

Wholesale broadband access bitstream

Wholesale broadband access (WBA) products using the current copper access network (based on the LLU remedy from the Wholesale Local Access market) can provide bitstream access (Figure 2.2). If MDFs are phased out in a NGA environment, the importance of WBA as a means of facilitating competition at a regional level will increase, especially if alternative operators are not able to roll-out their networks towards the street cabinets. WBA products offer the opportunity to enter the broadband market without the need to deploy an access network. WBA products require only a limited number of interconnection points to provide nationwide coverage. As such, WBA products can be used by new providers entering the market, or by providers wishing to offer services in exchange areas where they have not deployed their own access network. In view of the economics of providing full national coverage by deploying alternative access networks or via LLU, some providers except the incumbent are likely to be dependent on WBA products to provide service on a national basis.

Figure 2.2. WBA products using current generation copper access network



Source: Ofcom (2010b).

With WBA, however, the customer access is controlled by the WBA product provider, allowing far less scope for innovation by the interconnected connection provider than it could achieve by deploying its own network. Differentiation can be offered only at the services level. In order to maintain as far as possible the benefits of infrastructure competition based on LLU, the design of the WBA product may need to be enhanced to deliver an as close as possible level of innovation capability to operators, enabling them to differentiate their service offerings and compete as far as possible on an equivalent basis to the infrastructure owner. Even an enhanced WBA product, however, will give alternative operators less functionality control and is therefore probably never a full substitute for LLU. It remains a “managed” wholesale access service while unbundling provides more control.

2.3. Pricing

Pricing issues will need attention in a NGA environment. For instance, the pricing of access, *e.g.* access to unbundled fibre networks, is crucially important in influencing market structure and competition[25] as is price regulation to constrain ‘margin /price squeeze’.[26] However, margin squeeze may be better dealt with through antitrust enforcement.

The delicate balancing act which national regulators must perform to stimulate investment whilst encouraging innovation and competition includes the task of fixing appropriate wholesale prices, namely how best to incentivise copper replacement by fibre networks, in the absence of substantial government funding. During the transition from copper to fibre, two networks will be run in parallel for a time and this will tend to accentuate the effect of wholesale charges that are either too high or too low. Too high a wholesale copper price may reduce customer demand, forcing them to seek alternatives. But there is a risk that where incumbents’ margins are high and legacy networks are profitable, they will have increased incentives to retain use of copper networks, with reduced incentives to invest in fibre. Too low a wholesale copper price may, however, reduce margins on existing networks such that it deprives incumbents of funding for new fibre infrastructure. Another possible solution would be price-based competition with other platforms (e.g., cable) stimulating FTTx deployment without significant regulatory intervention.

Some principles from the PSTN world may be appropriate and others may need to be reconsidered. While this paper acknowledges the need to maintain investment incentives as well as the need to regulate wholesale services (*e.g.* unbundled fibre loops) where competition is insufficient, it does not address in detail how wholesale prices should be set. This subject is expected to be considered in future OECD work. Some issues likely to be considered include the appropriateness or length of regulatory holidays on pricing for new fibre investment; the incentives different levels of wholesale prices give for market players to invest in new infrastructure *vis a vis* the regulated prices of existing copper facilities, etc. and so forth.

Prices for access must be set to ensure no opportunity for margin squeeze. This is essential to ensure there is effective competition in services at retail level. Where cost orientation is required to avoid excessive pricing, this should be calculated to ensure a fair return, which reflects any risk incurred appropriately.

Non-discrimination needs to be preserved. Differentiated terms, such as discounts for participation in a co-operative arrangement, or for long term or committed volumes, must be compatible with promoting effective competition.

The cost methodology guidelines for wholesale price regulation are critically important. Key questions that need attention include:

- Which asset valuation method should be used, historic (HCA) or current (CCA) costs.
- Whether LRIC (Long Run Incremental Cost) or FDC (Fully Distributed Costs) allocation methodologies should be pursued; and
- Whether ‘top-down’ models based on actual accounts or theoretical ‘bottom-up’ models are more appropriate.

For example, if instead of using historic cost, or written down cost, of copper networks, operators were allowed to use the hypothetical current cost of installing new copper networks, as some have suggested, this might lead to price regulation at a level unrelated to the costs of an optimally efficient operator. This may not make commercial sense, as no sensible operator would contemplate undertaking a copper installation project now. Such a cost methodology could therefore be inappropriate.[27]

As fibre and copper networks have different characteristics both technically and from an economic viewpoint, separate cost models could be prepared for copper access and FTTH. This might help ensure that dominant firms are not compensated in advance for non-existent FTTH networks and that consumers and competitors unable to take advantage of FTTH capacities do not have to pay for such capacities. Legacy assets that will not be replaced or upgraded, including ducts and copper, should be priced no higher than the level that compensates the dominant firm for the actual costs they incurred, including a fair cost of capital, but excluding supernormal-profits. Such prices could be set using top-down LRIC with Historical Cost Accounting (HCA) asset valuations, or should not exceed such levels if other methodologies are used. The wholesale price for services based on modern assets including FTTH could be based “top-down” on the actual business plan for the area covered (HCA=Current Cost Accounting [CCA] in this case). In Australia, there has been recent attention to the appropriate cost basis for access pricing. The Australian Competition and Consumer Commission (ACCC) has pointed out that the cost concept being used at present, TSLRIC+, is the incremental or additional costs the firm incurs in the long term in providing the service, assuming all its other production activities remain unchanged. TSLRIC+ pricing is based on ‘forward looking’ costs which in practice often means basing costs on the best-in-use technology and production practices and valuing inputs using current prices. The ACCC considers, however, that it is time to review the continued application of a forward-looking TSLRIC+ approach because the continual revaluation of network assets means that there has been ongoing uncertainty over the level of access prices. It has also increased the risk of over – or under-recovery of costs by the access provider. If input prices are falling and straight-line depreciation is used, then resetting prices before the end of the economic life of an asset will result in under-recovery.[28] Given that existing assets are revalued at optimised replacement cost, the current implementation of TSLRIC+ may have resulted in the past depreciation of existing asset values not being taken into account in the revaluation of network assets in each regulatory period. This may have resulted in over-recovery by the access provider.[29] Calculating forward looking costs involves estimating the cost of providing the relevant service using modern equivalent assets (MEA). There is considerable debate regarding what constitutes a MEA.

Under the TSLRIC+ approach adopted by the ACCC, regular revaluations of infrastructure assets resulted in valuations of the access provider's assets which arguably were significantly above the access provider's actual cost of those investments. This is because the cost of replacing the infrastructure that provides fixed line services has been driven by increases in the costs of the largest components of fixed line services, such as ducts and pipes, rather than decreasing, as was assumed when the regime began. In addition, the access provider has continued to receive a return on and of capital on assets that have continued in use well beyond their economic lives (as originally assumed for depreciation purposes). Pertinent to this report is that where, as in a NGA environment, it is unlikely that competitors will build alternate access infrastructure, a replacement cost access pricing approach, with its rationale of providing efficient 'build/buy' signals, may be less applicable.

2.4. Network Neutrality and access regulation

A number of network operators have raised the issue of how NGA networks will attract investment, in relation to the services offered over those networks, the quality offered for those services and the possibility to introduce differentiated pricing for the carriage of some services. A recent example is a report by AT Kearney, for four European network operators, "A viable future model for the internet", which links investment in new infrastructure and access regulation.[30] The discussion and debate around these issues is not solely one for NGAs or any particular technology. Discussions related to the "Internet model" have been ongoing since it became a commercial network. While different titles are used (*e.g.* "net neutrality", "open Internet", "viable networks" and so forth), a key aspect of the debate relates to the investment that will be required for NGA networks and how this relates to the aims policy makers have for NGA such as promoting improved services at competitive prices. Policies on 'network neutrality' become increasingly significant where, as may be the case with NGA, the number of networks, and thus the number of competitive access providers, are limited. These policies should seek to ensure that access providers do not discriminate against third party service providers that compete against the access providers' own services or otherwise discriminate among service providers in the provision of 'like' services.[31]

Box 2.3. Network neutrality

While it is true that there is no clear definition of “net neutrality,” under one definition of net neutrality, providers would be “truly neutral” and would not be allowed to manage or block the traffic on their networks. In this view, the issue of “network neutrality” concerns whether access providers may prioritise some types of traffic or slow it down, according to certain criteria (*e.g*. willingness to pay, bandwidth management, etc.) or, on the contrary, Internet traffic should be treated as “neutral”. Policies on ‘network neutrality’ become increasingly significant where, as may be the case with NGA, the number of networks, and thus the number of competitive access providers, are limited. These policies should seek to ensure that access providers do not discriminate against third party service providers that compete against the access providers’ own services or otherwise discriminate among service in the provision of ‘like’ services. For instance, under willingness to pay arrangements, those service providers paying more, to the access provider, would receive prioritised (thus faster) access to end customers. Internet access, for those customers, would then be separated into “layers” according to the priority given to a specific type of traffic by their service provider. To the extent that providers are allowed to manage their networks to improve quality, the issues become: *i*) whether there should be limits on the ability of providers to discriminate for or against certain types of traffic (*e.g*., favouring real time applications) or particular providers of certain types of traffic (such as a competing provider of over-the-top video; and *ii*) whether a broadband ISP should be allowed to charge an upstream content, service, or application provider for prioritisation.

Some network operators, such as Telefonica, Deutsche Telekom and Vodafone, have indicated that they may charge tiered levels of pricing, for some types of services. In August 2010 Verizon and Google advanced a model for what they described as an open Internet. They said that while they had not observed the slowing of traffic, over the Internet, such practices would be unacceptable. They advocated leaving room for additional or differentiated services that would have to be distinguishable in scope and purpose from the provision of broadband Internet access. The two entities also suggested the issues considered may be different across platforms, such as whether fixed or mobile networks are under consideration. The Verizon-Google proposal stated that network neutrality-related rules should not apply in the context of mobile at this time.[32] The European Commission has launched a consultation in order to take forward Europe’s net neutrality debate, covering the convenience of ISPs adopting traffic management practices, any possible harm for users, impact on competition in conjunction with the new European regulatory framework and whether the European Union needs to act on this issue. The European Union has expressed its commitment to an open and neutral Internet, while acknowledging the complexity of the issue. Chile’s Parliament has recently passed an amendment of the General Telecommunications Law, stating that ISPs must not interfere, discriminate against or hinder access to content, application or services, except for security reasons.

In December 2010, the Federal Communications Commission introduced measures it said would ensure the openness of networks to continue enabling consumer choice, freedom of expression, user control, competition and the freedom to innovate. This followed a public process to determine whether and what actions might be necessary to preserve the characteristics that had underpinned the successful growth of the Internet. The FCC noted that blocking or degrading content and applications without disclosing such practices to consumers could threaten Internet openness. This might, for example, arise if broadband providers had financial interests in services that competed with online content and services of third parties. A key aim of the FCC, in adopting its order, was to provide greater clarity in this area: “…clarity that the Internet’s openness will continue; that there is a forum and procedure for resolving alleged open Internet violations; and clarity that broadband providers may reasonably manage their networks.” The Order adopted three basic rules: transparency of network management practices, no blocking of lawful content, and no unreasonable discrimination. The rules are subject to reasonable network management and apply differently to wired and wireless broadband Internet access services.[33]

Network neutrality, in respect to traffic prioritisation, raises a complex set of issues that need to be considered by policy makers and regulatory authorities, including the level of competition which is available for broadband access. The litmus test is undoubtedly whether any intervention is beneficial for consumers. In drawing conclusions on this, factors that will need to be taken into account include how any action may affect outcomes such as investment, at all levels of the value chain, as well as whether any initiative would assist or hinder the Internet’s ability to be a platform for innovation. Given the range of issues that need to be considered, OECD countries will benefit from a broad debate that will foster the principles on which an open Internet will be based.

SECTION 3. NGA ECONOMICS, MARKET STRUCTURE AND INVESTMENT IN A NGA ENVIRONMENT

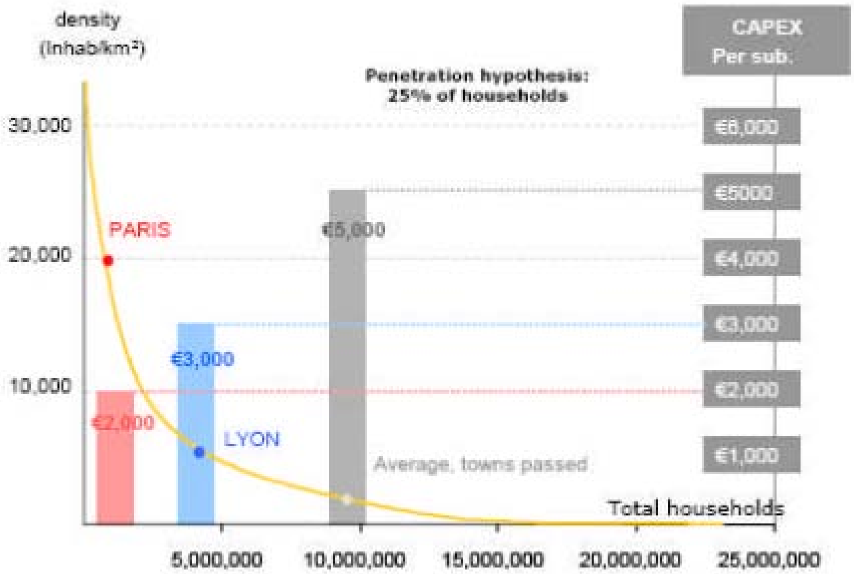
3.1 The economics of NGA

Broadband network operators have said that, in many geographical regions, the cost of deploying NGAs is too high relative to the expected revenue so that investment would be unprofitable. Because of high fixed costs of deployment, unit costs decrease as population densities increase and loop length (a main driver of costs) decreases.[34] Thus, NGA deployment is generally more profitable where potential demand is higher and concentrated, *i.e*. in densely populated areas, where an operator already has a substantial base of broadband customers who can be migrated to the higher speed service. As a result, NGA networks tend to be able to profitably cover only parts of a country. In certain areas, it may only be profitable for a single provider to set up a network.

The economies of scale and scope of NGA investments are likely to reduce the degree of replication, potentially leading to an enduring economic bottleneck. The extent of economies of scale mean that in certain locations there may be natural monopoly (or duopoly) features in a NGA network. Neumann concludes on the basis of considerable modeling-based research that the economics of FTTx do not support multiple replication of the access network sufficient to achieve effective competition.[35] In the case of (theoretical) replication usually only one or in rare cases two operators (in addition to the first mover) can profitably invest in NGA infrastructure. In any case, replication is limited to denser populated areas.

An illustration can be provided of the decline in capital expenditure per subscriber in relation to population density (Figure 3.1). For instance, an important element of costs for the FTTH scenario, civil engineering costs such as trenches or ducts per subscriber, is inversely related to urban density. These costs can constitute between 50% (in Paris, due to the use of the sewer system) and 80% of the total cost per customer depending on the population. The cost associated with the vertical roll-out (for in-house wiring) is also important.

Figure 3.1. CAPEX (per subscriber) vs. total households/density
(Based on 2007 data)



Source. ARCEP reproduced in ERG (2007) 16rev2 16/66

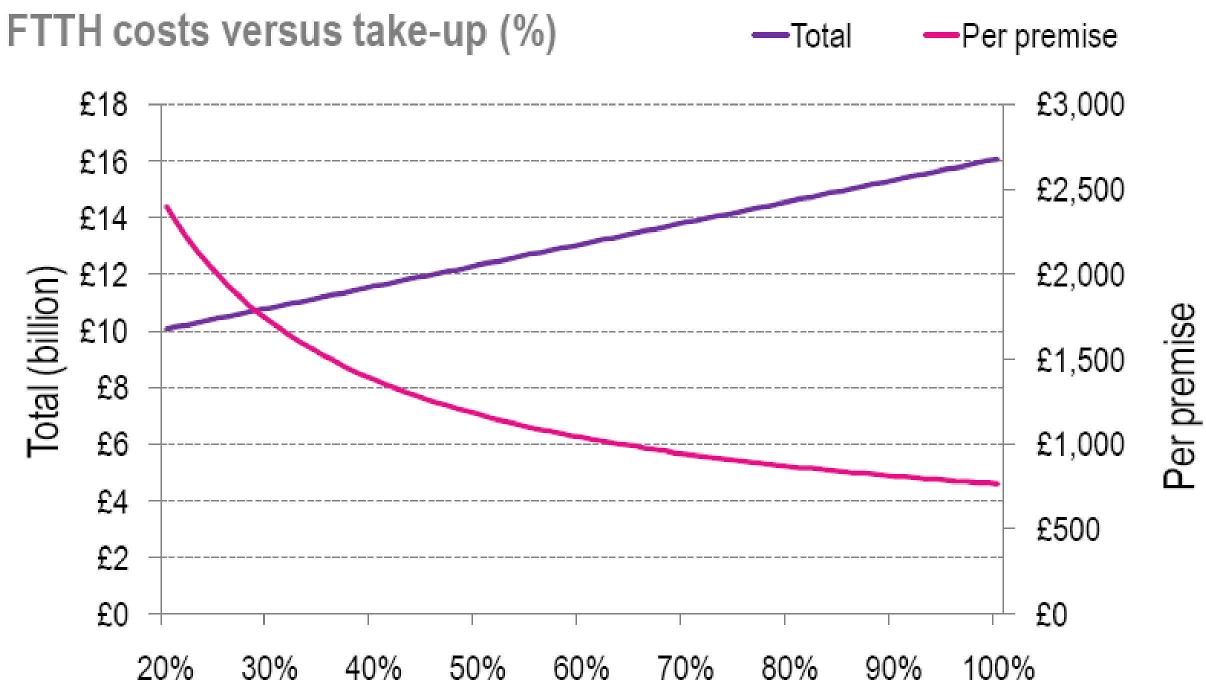
Figure 3.1 should be regarded as illustrative only as the data upon which it is based was derived in 2007 and may no longer hold. More recent estimates and information available from operators suggest that the costs of NGA deployment per subscriber indicated in Figure 3.1 appear to be considerably higher than their current experience.[36]

The nature and extent of economies of scale and scope in NGA investment have significant implications for market structure. Incumbents can make better use of economies of scale and scope due to their larger subscriber base, frequently 80-90% of local loop and about 50% of retail broadband customers which they can switch to NGA. This frequently compares with only around 10% to 15% of market share for the leading competitor. For FTTH, optical fibre has to be laid from the exchange along the entire route right up to the end user's home. Accordingly, the owner of the local loop has greater prospects of implementing these investments compared to other operators, *e.g*. due to ownership of the utility easements and ducting. These potential savings may be as much as 70% of current operating costs. Also, as exampled by KPN in the Netherlands, it may be possible for incumbents to generate funds from the sale of the real estate the MDFs' occupy (if the MDFs are dismantled) that could be made available for NGA investment.[37] Furthermore, due to their smaller size and higher risk position, competitive operators usually face a higher cost of capital than incumbents.

The commercial attractiveness of a FTTH deployment depends not only on cost factors but also on revenue and this depends on the penetration rate, market share and the possibility of realising a higher revenue per customer (Figure 3.2). Where FTTC/VDSL is deployed, this requires much less investment than FTTH due to saving on the distribution cable segment enabled by using the existing copper sub-loops and saving on the in-house cabling. [38] In fact, according to one estimate, FTTH could cost several times more than VDSL. Point-to-Point FTTH architecture – which is more future-proof and amenable to open access regulation – requires less than 10% additional investment than the PON architecture.[39]

The profitability of VDSL roll-out depends on several factors, in particular: population density; customers who can be reached per node; penetration rate; market share; and ability to increase ARPU. Some have concluded that the profitability of the incumbent's VDSL roll-out depends crucially on the demand for VDSL access. The critical penetration rate required for a breakeven of the incumbent's VDSL roll-out ranges from 14% to 31% of all households passed.[40]

Figure 3.2 The sensitivity of FTTH total and per premise cost to take-up



Source: Plum Consulting (2008), *A Framework for valuating the Value of Next Generation Broadband*. A report for the Broadband Stakeholders Group,. June.

Other significant cost components for the FTTC/VDSL scenario are the costs of the DSLAM and other electronic equipment (*e.g*. modems), and co-location costs. Given that the number of FTTC/VDSL customers that can be reached is considerably smaller per node than per MDF, the viability of a business is significantly affected by the number of street cabinets per MDF which can range from 10 in France to around 14 in Italy, 16 in the United Kingdom, 21 in the Netherlands, and about 40 in Germany. Other relevant parameters are the length of the backhaul segment and the length of the loop between cabinet and end-user. Although reasoning based on the average number of street cabinets per MDF may be relevant in urban areas, distance-related criteria should also be taken into account in the assessment of less densely populated areas.

Unless regulation requires the incumbent to provide access to its street cabinets, the option of deploying a VDSL network of their own may not be available to all or most of the LLU operators active today. But even here there could be problems because economies of scale are much more significant for sub-loop unbundling than for LLU.[41] In a case study for the Netherlands, it was estimated that for sub-loop unbundling (SLU) they are still significant even with well above 1 000 customers per exchange, while for LLU they are typically exhausted with 500 customers.[42] Thus, a small competitor is likely to be at a disadvantage relative to a larger incumbent. The study concluded that the use of SLU by an alternative provider is unlikely to be commercially viable as an alternative to continuing the use of LLU, except under certain conditions (requiring a significant market share or ARPU increase). Considering the effects of strong local economies of scale, even cuts of 50% in KPN's wholesale tariffs would not be sufficient to make SLU a viable alternative to LLU.[43]

In view of the relatively limited prospects for upgraded cable broadband service in most OECD countries (although there are exceptions such as in Belgium, Canada, the Netherlands and the United States), and developments in wireless technology, fixed line next generation broadband is likely to see only limited scope for competition in many areas, and little prospect for deployment of new competing fibre networks in the same location.

The ability to replicate a particular type of asset may vary in different circumstances.[44] For example, local access networks may be more "easily" replicated in geographic areas with a high population density or because of different competitive situations *e.g.* from cable. The term 'replicate' is used here to include other infrastructure capable of delivering the same services. Thus, the duplication does not need to be on the basis of the same technology and, even if it is, there is no assumption that it will be configured in the same manner. It is likely that there will be a variety of different approaches utilising a mixture of technologies depending on specific local characteristics, including copper local loop and sub-loop lengths, customer density and dispersion, presence of multi-dwelling units, and the quality and topology of existing network architecture, in particular the number of street cabinets per MDF. Consequently, competitive circumstances too may vary. This might suggest geographically segmented regulation with sub-national markets formally defined, or differentiated regulatory remedies within a single national market.[45]

There are a number of factors beyond the economics of NGA networks that can affect their deployment, including: physical limitation of space in the street cabinets; utility infrastructure, including sewers, water, gas and electricity distribution networks; ducts and infrastructures, owned by municipalities/(public) utilities; in-house (building) infrastructure; property rights of municipalities (installation of additional street cabinets); access to in-house wiring; publicly funded infrastructure (possibly crowding out commercial NGA roll-out). Municipalities also play an important role as they, in general, decide on rights of way, and thus may be able to block the deployment of larger or more street cabinets. Other players whose property rights might pose difficulties are house owners, *e.g.* for in-house (fibre) wiring. Possible ways to overcome these "barriers" could include arrangements with municipalities and/or commercial solutions between operators.

3.2 Implications of NGA economics and technology for market structure

Neumann's study concludes that a nationwide NGA roll-out is not profitable in any of the six countries analysed, namely France, Germany, Italy, Portugal, Spain and Sweden.[46] Others note, based on experiences since that time, that the estimates for costs may have been too high and therefore, the estimates of how much of a country could be covered, by (competitive) NGA's, too low. Most notably, the numbers for Portugal and France appear to be contradicted by the current investment of various market participants.

One issue that has been raised in relation to the study is that if PON was less expensive than Point-to-Point, it is not clear why viability percentages are the same for Sweden (SE), Portugal (PT) and Spain (ES) (Table 3.1). That being said, the study is quite unique in the breadth of OECD countries it covers and in its use of specific methodology to evaluate the prospects for NGA deployment in these countries. As such, it can be used to illustrate the arguments, even though the specific costs may not be correct.

The area of NGA coverage beyond the level of profitable roll-out can only be expanded with support from public funding or subsidies. The results also show for all three architectures, VDSL, PON and Point-to-Point, the coverage areas that can be profitably served. According to Neumann's analysis, the incumbent in Germany can profitably roll-out VDSL for 71.5% of the population while viability in Sweden ends at 18.3% of population. A FTTH roll-out is much less viable and is in the range of 12% to 25% across the six countries. Importantly, Neumann's study indicates that replication of the incumbent's NGA requires a more significant scale and/or market share for alternative operators compared with current business models based on local loop unbundling. This limits the number of feasible competitors in the access network. The conclusions of the Neumann study should, however, be considered with all necessary caveats. Indeed, when compared to the NGA roll-out announcements of private operators, these results appear slightly pessimistic. For example, France Telecom's 40% FTTH coverage plans for 2015 is significantly higher than the 25.2% population coverage that is estimated to be viable for GPON operators according to the Neumann study.

Table 3.1: Viability of NGA roll-out for incumbents across countries and technologies (% of population covered)

Network Type	Country					
	DE	FR	SE	PT	ES	IT
VDSL	71.5%	n.r.	18.3%	39.0%	67.4%	100.0%
PON	25.1%	25.2%	18.3%	19.2%	12.2%	17.6%
P2P	13.7%	18.6%	18.3%	19.2%	12.2%	12.6%

Note: n.r. = not realisable. DE = Germany, FR = France, SE= Sweden, PT = Portugal, ES = Spain, IT = Italy.
Source: Neumann, K-H (2010), p. 8.

One view of the viability and potential duplication of a second mover's NGA roll-out can be shown (Table 3.2). These results are provided for the optimistic scenario that the second mover has access to 80% of existing ducts. VDSL in Portugal is replicable for 39% of the population and for 18.5% in Germany. Across all six countries there is only relatively low potential replication of FTTH infrastructure, for 6.8% of the population in France and for only 0.3% in Germany. Duplicating the incumbents' VDSL network roll-out by alternative operators is less viable than the current LLU approach of alternative operators. In a VDSL NGA environment, the current degree of LLU based competition does not seem to be duplicable. These results are similar to those generated in studies for NRAs in the Netherlands, Ireland and Belgium. As noted earlier, civil engineering cost and in-house wiring are key barriers to replication in FTTB/H NGA deployment. Neumann concludes, however, that even addressing these barriers by regulatory measures alone will not be sufficient to deliver competitive outcomes.

It has been suggested that incumbents can reduce their own costs by infrastructure sharing, can increase the profitability of their NGA roll-out, and can reach profitability with a lower level of retail market shares if they provide wholesale services.[47] This analysis further suggests that open access regimes may support rather than undermine the investment case of incumbents, while delivering market outcomes that are more compatible with effective competition. For instance, in the case of Portugal (Table 3.2), one analysis suggests that if it is only duct access that is made available, the presence of a second fibre access provider would significantly improve the incumbent's profitability but the market structure would tend to support only two significant fibre operators.[48] One the other hand, while infrastructure sharing can lower costs, it can also reduce revenues. This means that the net effect on profits seems unclear, unless one assumes that the competitors would be present even without infrastructure sharing.

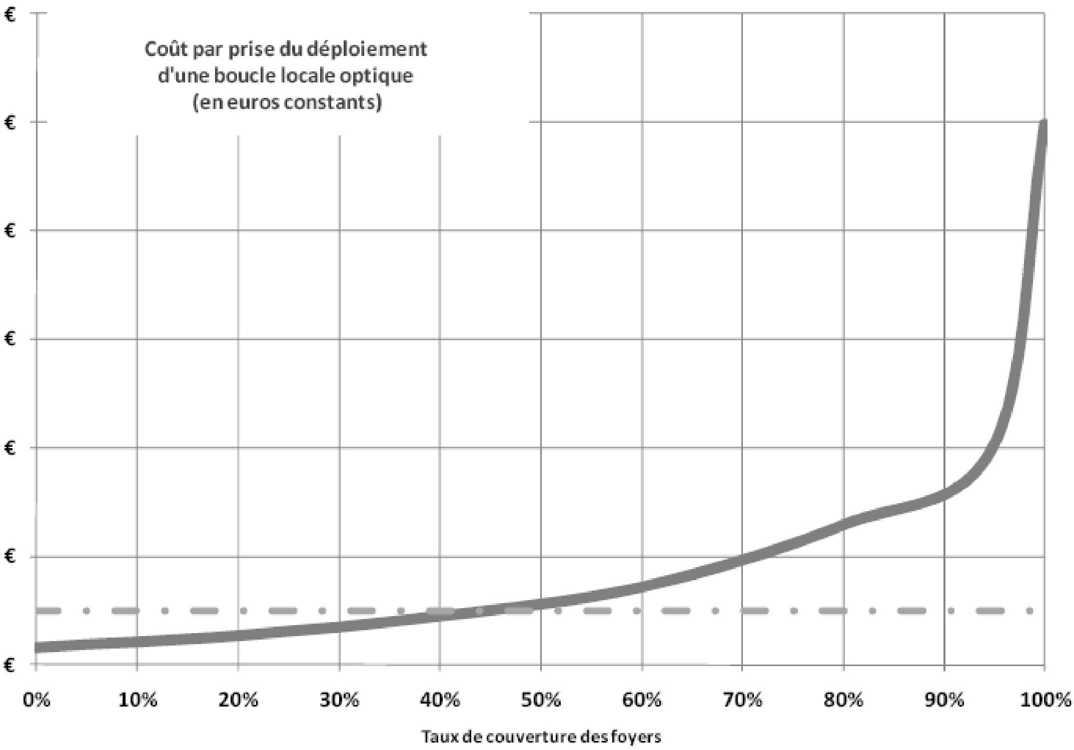
Table 3.2: Viability and potential replication of second mover's NGA roll-out, 80% access to existing ducts

Network Type	Country					
	DE	FR	SE	PT	ES	IT
VDSL	18.5%	n.r.	n.v.	39.0%	n.r.	17.6%
PON	0.3%	6.8%	n.v.	n.v.	n.v.	1.6%
P2P	0.0%	6.8%	n.v.	n.v.	n.v.	0.2%

Notes: n.v = not viable. n.r = not duplicable. DE = Germany,
FR = France, SE = Sweden, PT = Portugal,
ES = Spain, IT = Italy.
Source: Neumann, K-H (2010), p. 9

If wholesale fibre LLU or SLU were available, this would lower the critical retail market share for the incumbents' profitability whilst supporting a number of additional operators. Effective access remedies and/or wholesale products would increase the potential for replication of NGA access infrastructure and therefore the degree and potential for competition. Regulatory measures relating to the use and sharing of infrastructure can result in more efficient networks, depending on the architecture, to increase the efficiency of NGA investments. Efficient backhaul solutions between the street cabinet and the operator's network node are crucial. Duct and dark fibre access increase the capability for infrastructure to be economically replicated, but are alone not sufficient for viable competition. Physical co-location at the street cabinet level increases the limited degree of replication possible in the case of FTTC. Fibre-full local loop unbundling (at metro core locations) and fibre sub-loop unbundling increase the scope for competition significantly. Bitstream access remains important where unbundling is not technically feasible *e.g.* in less urban areas where unbundling is not economically viable and for business service providers. In addition, the regulatory framework has to deal with the sunk investments of competitors related to LLU infrastructure to enable a viable migration path to NGA.

Figure 3.3 Cost per subscriber of NGA deployment in France according to extent of coverage



(Cost of local loop unbundling (in constant Euro).

Source: Study by TACTIS for DATAR, January 2010.

3.3 The economics of multi-fibre deployment

The European Commission has recommended the deployment of fibre not as a single fibre connection between the customer and a network node but by installing a number of fibres to one single end-customer.[49]

Benefits to competition and consumers

Multi-fibre architectures deploy more than one single fibre per home, *e.g.* four, in the drop cable segment and (optionally) in the feeder cable segment, in order to enable several operators in parallel to get access to the same end customers. This provides an operator with end-to-end independence, allowing them to freely implement their technology (*e.g.* PON vs. Point-to-Point, or connection with or without a cross connection box) and thereby to differentiate themselves from other providers. The system is said by some to benefit consumers because they can switch operators quickly and without any interruption of service. This is because no adjustment is needed to be made on the network and because, unlike with unbundling, prior cancellation is not necessary. Through this means it is hoped to offer the end customers a wider choice – on the infrastructure level through the four operators.

In Switzerland, a multi-fibre deployment model has in fact been in use for some time. In response to the plans of some local utilities to roll-out fibre networks in some major cities, Swisscom stopped the further roll-out of FTTC/VDSL in 2008 and announced an extensive FTTH network roll-out. Swisscom has deployed a FTTH Point-to-Point network architecture and is connecting each home using a multi-fibre approach with four fibres from a manhole into each home. Co-investment arrangements with other operators are negotiated to share the costs of terminating fibre segments with these partners.

In sharing investment costs, the first partner pays the investor 50% of the investment cost plus a margin to cover the project-specific investment risk. A second partner has to pay 33% of the investment cost plus the margin. The payment of the second partner is shared between the investor and the first partner. Swisscom assumes that the total investment cost will increase by between 10% and 30%. Compared to the single fibre architecture, the investor has to bear only 55% to 65% of the total investment. The same holds for his investment partner. Both partners can reach 100% of the potential customer base at a lower investment than on a stand-alone investment.[50] The basic economic advantage for the individual operator is that under a multi-fibre approach it only has to bear a certain proportion of the investment, but still can reach 100% of the potential customers. Fibre investments in a multi-fibre sharing arrangement can increase duplicability since the critical market shares for an individual operator for profitability are lower. Nevertheless, the areas where each of two or even four operators reach the critical market shares for profitability are rather limited.

Advocates of the multi-fibre model argue that it has the following advantages:

- It provides a prospect of duplication of the fibre at lower costs than the end-to-end infrastructure duplication.
- The competitive operator has a better end-to-end control over its network infrastructure. This is conducive to long-term sustainable competition
- It can facilitate competition since the customer can get different services from different operators.
- It potentially can contribute to the solution of the termination monopoly problem. A user could, for instance, subscribe to different termination services from different operators.
- In the deployment of NGA networks, multi-fibre lines support both "point-to-point" and "point-to-multipoint" topologies and are therefore, at one level, technology neutral.

Besides the additional investment involved, however, a multi-fibre approach is seen to have some drawbacks.[51]

- The higher level of sunk investment required because of the cost-sharing involved in multi-fibre arrangements can generate a significantly higher barrier to entry and increased penetration risk for new, potentially small, entrants.
- In the unbundling model, the number of competitors is determined by the market. In a multi-fibre model unconstrained by regulation, the maximum number of competitors is determined *ex ante* by the investor and his decision on the number of fibres to be deployed. However, this restriction might be overcome by a secondary market for fibre lines, *e.g.* on the basis of unbundling, in particular, if unbundling is mandated.
- Depending on the distribution of market shares, the multi-fibre model can cause significant asymmetries in per line costs and therefore in competition and this can undermine sustainable competition.

WIK concludes that multi-fibre costs between 10%-20% more than Point-to-Point fibre but that multi-fibre may only be viable in circumstances where operators already have roughly equal market shares.[52] Since this is rarely the case (for instance, in Europe, except the United Kingdom, incumbents have an average 45% share compared with 10% or less for each non-cable entrant), there may be little incentive for entrants to participate because they would be subsidising the capital expenditure of the dominant firm whilst lacking sufficient economies of scale to make a profitable investment. Even in a situation where operator shares are evenly distributed and multi-fibre would be viable, there are concerns about entry barriers locking in an oligopoly. Thus while multi-fibre can help, it cannot be assumed to by itself deliver competition. This suggests that policy makers should consider requiring line-by-line unbundling.

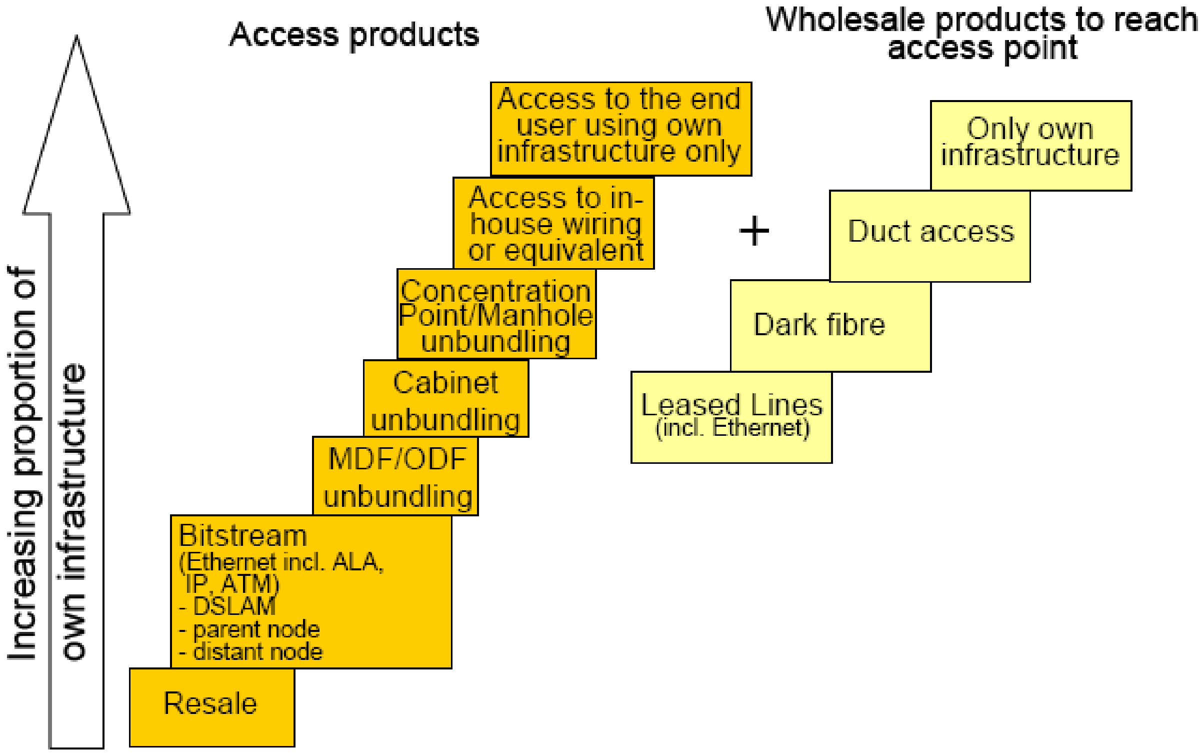
While the multi-fibre approach seems to have significant competitive advantages, barriers to entry could increase because of the upfront cost-sharing involved.[53] Also, unbundling allows as many competitors to directly connect end-customers via physical passive infrastructure as competitors are willing to co-locate at MPoPs. The multi-fibre infrastructure, however, only enables up to four operators to directly address end customers, unless one or more of them offer fibre LLU by themselves or an operator with Significant Market Power (SMP) is obliged to do so. The unbundling model is open to a variety of market structures and allows scope for the most efficient market structure to emerge. The multi-fibre model on the other hand may tend to result in a duopoly or oligopoly market structure and there can be a tendency towards collusion.

If policy makers and regulators decide that traditional infrastructure competition will not result in competitive NGAs alternative options may be required. An approach that ensures that the various options are available would expand the scope for market structure to be determined through a competitive process. This could involve requiring Point-to-Point and LLU by an operator with significant market power and also multi-fibre deployment as well as the Virtual Unbundled Local Access (VULA) and Physical Infrastructure Access (PIA) options advocated by Ofcom (2010c). VULA provides a connection from the nearest 'local' aggregation point to the customer premise. PIA is an obligation under which BT would be required to allow competitors to deploy NGA networks in the physical infrastructure of its access network (Ofcom 2010c).

3.4 *Ex ante* access regulation and the ladder of investment in a NGA environment

The ladder of infrastructure investment models assumes that investments are made in a step by step manner by new entrants.[54] The model argues that in order to allow new entrants to gradually (incrementally) invest in their own infrastructure they need a chain of (complementary) access products to acquire a customer base by offering their own services to end users based on (mandated) wholesale access. In those instances where duplication[55] of access is not considered feasible, promoting service competition is an important goal for the regulator because service and infrastructure competition are not opposed to each other. They are linked through the ladder of investment, allowing competitors, through a sequence of regulated access products, to invest in a step-by-step manner in their own infrastructure. Once they have gained a critical mass, they will deploy their own infrastructure making them less dependent of the incumbent's infrastructure. This involves migration from one access product to another (moving to the next rung) with the entrant progressing through several stages of competition as it ascends a "ladder" of infrastructure investment (Figure 3.4).

Figure 3.4 NGA Ladder of investment



Source: ERG (2009).

The ladder of investment rationale remains valid in an NGA environment although it may become more "sophisticated" and the relative importance of the rungs may change in an NGA environment, with several rungs requiring more investment in own infrastructure the higher the rung reached.[56] Notably, in a NGA environment, LLU might no longer be feasible. In Point-to-Point solutions, it may be possible to unbundle the local loop in a manner very similar to that used today for copper with full LLU of the loop applied from the ODF. However, in point-to-multipoint solutions (shared infrastructure topology, such as PON), it is no longer easily possible to associate a single physical element of connectivity with a particular end-user. In this situation, options for unbundling become more challenging. Unbundling of the subscriber fibre loop could be done at the passive optical splitter level, where the dedicated end-user fibre is connected to the shared fibre (connecting the splitter and the ODF).

In case of sub-loop unbundling, it takes place at the street cabinet and this is a further step that could be inserted in the ladder. In the FTTC scenario, the alternative operator would unbundle at the street cabinet and a complementary backhaul service/duct sharing is needed. In the FTTH/B scenario, the operators would roll-out fibre up to the building or house and complementary duct/in-house wiring sharing might be needed. This move could also be made in the FTTC scenario in a second step (Figure 3.4). Where faced with reconfiguring or phasing out of the SMP operators' MDFs in the FTTC scenario, the competitive operator can either climb up the ladder, by further investing to access the street cabinet, or remain at the MDF or the closest aggregation node and use Wholesale Broadband access (WBA).

Ofcom advocates, for example, that regulators consider the use of Virtual Unbundled Local Access ("VULA") and Physical Infrastructure Access ("PIA").[57] Ofcom considers that VULA would allow competitors to deliver services over the new NGA network of an operator with significant market power with a degree of control that is similar to that achieved when taking over the physical line to the customer.

PIA would allow competitors to deploy their own NGA infrastructure, between the customer and the local exchange, using the incumbent's duct and pole infrastructure. PIA could be attractive to companies wishing to address market opportunities in advance of the incumbent and may also be of particular interest to companies wishing to provide services in locations that may be receiving government funding support. In the case of current generation broadband, WBA has been seen as a lower rung of the ladder of investment than LLU. However, as noted earlier, if MDFs are phased out, the importance of WBA may increase, especially if alternative operators are not able to roll-out their networks towards the street cabinets. To maintain infrastructure competition based on LLU, the WBA product may need to be enhanced to allow alternative operators more control of quality parameters. As some alternative operators will not move to the street cabinet, but make more use of such an enhanced Bitstream product, while others will invest in their own infrastructure and move further down to the customers, differentiated markets will emerge. However, even those who do invest will not do so everywhere but only in those areas where the economics will allow a business case, *i.e*. to street cabinets with a minimum number of customers which can be reached. In order to reach national scale, these operators will draw on BSA products (and other access products) too in areas where they do not roll-out to the customers to complement their offers.[58] Competitive conditions are likely to vary in different parts of a country, the national market structure may become more heterogeneous as the NGA roll-out may not happen everywhere and there may be a need to consider geographically segmented/differentiated regulation.

3.5 Platform transitions as a factor in the economics of NGAs

A key issue for the development of NGA is take-up and market acceptance. Some analysts suggest that to be economic an NGA adoption needs to be more than 50% of the total potential customer base.[59] By the end of 2009, only Japan and Korea had reached more than 50% of all broadband subscriptions. In relation to market structure, these countries are providing experience for others in respect to how many operators are economic – though in areas with among the highest population densities in the OECD area.

In countries where existing operators, with private investment, are upgrading infrastructure, transitional developments will proceed incrementally. In countries such as Australia, where NGAs are being built with the involvement of a new infrastructure provider and independent service providers, in association with public investment, some additional issues may arise. These could include issues such as whether the PSTN will be retained for customers not initially wishing to take up the new offer; whether the change over would be the default position or not (opt in or opt out) and who pays for the maintaining or decommissioning of networks. The Australian Government is seeking to address some issues by negotiating an agreement with the incumbent carrier. The proposal is that the Government – through its newly created and government-owned wholesale only, open access carrier – will *i*) reuse, where suitable, the incumbent carrier's existing infrastructure, including pits, ducts and backhaul fibre, and *ii*) progressively migrate the incumbent carrier's customer services from copper and cable networks onto the new fibre network.

SECTION 4. FUNCTIONAL OR STRUCTURAL SEPARATION IN A NGA ENVIRONMENT?

4.1 Background to OECD's work on structural separation

The question of whether separation of vertically integrated incumbents' wholesale and retail divisions is warranted is not new and in fact different forms of separation have been introduced in a number of sectors and jurisdictions.[60] Indeed, the OECD itself has examined the question of structural separation for telecommunications operators a number of times in the last decade.[61]

In 2001, a Recommendation of the OECD Council concerning Structural Separation in Regulated Industries stated:

"When faced with a situation in which a regulated firm is or may in the future be operating simultaneously in a non-competitive activity and a potentially competitive complementary activity, Member countries should carefully balance the benefits and costs of structural measures against the benefits and costs of behavioural measures. The benefits and costs to be balanced include the effects on competition, effects on the quality and cost of regulation, the transition costs of structural modifications and the economic and public benefits of vertical integration, based on the economic characteristics of the industry in the country under review."

In 2003, the OECD produced a report that considered the costs and benefits of vertical separation of the local loop and concluded that the case for structural separation was not proven and compelling.[62] The OECD Council reaffirmed in 2006 its 2001 Recommendation that when considering remedial measures towards vertically integrated dominant telecommunications operators, member countries should carefully balance the benefits and costs of structural measures against the benefits and costs of behavioural measures.[63]

OECD countries have applied a range of 'behavioural measures' to foster competition in the telecommunications sector through efforts to achieve non-discriminatory 'equivalent access' to the local loop. But thus far, no OECD country has chosen to pursue the vertical structural separation of an established operator. Indeed, one of the arguments in the 2003 OECD report was that the absence of any member country that had actually imposed structural separation meant that there were few lessons or experience that could be drawn upon to help establish the demonstrated benefits and costs of structural separation in practice. In this regard the situation has not changed, although the first countries have introduced policies that will result in NGAs offering separate wholesale and retail services from independently owned entities. In addition, a number of countries have introduced functional separation to achieve the same affect.

4.2 Why examining the case for structural separation is different this time

The onset of next generation networks has raised again the question of whether vertical structural separation is required. There are several factors that are new compared with the situation when previous OECD work was undertaken.

One factor is that the previous work was in the context of the PSTN and copper loops which could be made available to third parties through local loop unbundling. As noted earlier, there are claims that the two most common technologies used to deploy NGA, namely FTTC and PON FTTH, make local loop unbundling more difficult. A form of sub-loop unbundling is possible for FTTC but this would cost far more than in current generation broadband networks so that, thus far, there has been little demand for it. In PON, different end-users share the same fibre so it is not possible to unbundle a single user – at least not at the moment. Ofcom has advocated the use of VULA to achieve virtual unbundling.

In the future, a form of wave length separation may make unbundling possible but some consider that currently the dense wave division multiplexing (DWDM) technology necessary to achieve this is too expensive.[64] Accurate costing is difficult to obtain and commercially sensitive but estimates of the current cost premium of DWDM over PON vary between 50% and 200%.[65] PON service providers will not therefore be able to continue to offer services using local loop unbundling or its equivalent. If wholesale access is required to support competition, it will need to be based at the electronic rather than the physical layer. But while such bitstream based service providers can differentiate themselves in terms of branding and bundling and to a certain extent in customer service they are dependent on the infrastructure provider for functionality, service information, costs and even fault-fixing.

A second factor, that is different now, is that there may be some evidence available from countries that have applied functional separation. This means the first evidence may be available on the effectiveness of functional separation in respect to NGA development. For example, does the mere ability of an authority to apply "structural separation" mean that operators are more likely to enter into voluntary functional separation – if that is judged by policy makers to be necessary for NGAs to develop in a way that promotes attributes such as competition and investment.

The European Union has installed functional separation as a last-resort remedy that regulators in its Member States can apply. Many OECD countries are not Member States of the European Union and this raises the question of whether they too should seek to have this authority. Or, indeed, whether there is a persuasive case for making the remedy of last resort not functional separation but rather structural separation? If this potential "last resort remedy" is needed it raises the question of whether such powers currently exist and, if so, with which agencies?

A third factor is that previous work on structural separation did not consider public investment in communication infrastructure. For much of the previous two decades the trend has been towards privatisation of telecommunication operators. Moreover, even in an era of public ownership and monopolies, telecommunication services were more frequently the source of revenue for public expenditure in other areas (*e.g.* health, education) rather than drawing directly from the public purse for infrastructure development. Recent developments with investment in broadband infrastructure have included significant public investment. This has included government directly investing in infrastructure providers to ensure either a split between wholesale or retail services, or a requirement for "open access" or "network neutrality", or network expansion into less commercially attractive regions.

Government investment in networks as a tool to determine market structure or the behaviour of firms is relatively new and novel at least in recent decades. If governments are investing in or building national NGAs it raises many new questions in relation to market structure. These include the role they envision both for themselves and the private sector and the time period this involves. It also raises the question, if functional or structural separation is planned of the role regulators will have in wholesale and retail markets.

Finally, previous work on structural separation considered the benefits and costs of splitting up an already established integrated network. In the context of NGA, the issue could be a prospective one involving the installation of a new separate wholesale operator deliberately separated from retail activity from inception, as in the case of Singapore's NetCo and NBN Co for Australia. Even with this perspective of a new NGA operator, there may be the question of whether an established vertically integrated legacy operator that continues to operate alongside the new NGA operator should also be structurally separated. This is a question that has been examined by the Singapore regulator through a public consultation.[66]

4.3 Functional and structural separation

Functional separation, sometimes referred to as operational separation, attempts to achieve non-discriminatory conduct of an operator with significant market power in the provision of access products and in downstream competition. It requires a dominant operator to separate, but not sell, its network infrastructure from its retail services division. The key feature of functional separation models is that the network provider is required to operate at arm's length from downstream service operators providing competitors and the incumbent's own retail operations with non-discriminatory equivalent service.

In May 2009, the European Parliament voted to make functional separation available as a regulatory remedy 'of last resort' to national regulatory agencies (NRAs) in European Union Member states where there are important and persisting competition problems and/or market failure identified in relation to the wholesale provision of certain access product markets.[67] Functional separation is intended to constrain discrimination and achieve full equality of access for all downstream divisions, including the downstream divisions of the incumbent operator. The burden of proof is on regulators to show that this "exceptional measure" is necessary and could not be addressed by less intrusive forms of regulation. The evidence to be submitted by regulators to the European Commission for consideration prior to the imposition of functional separation, includes: the existing state of competition in defined markets; the effectiveness of existing regulatory remedies (*e.g.* accounting separation) in addressing the identified competition problem; and the appropriateness of functional separation as a means of addressing the identified competition problem.[68]

Vertical structural separation

Structural separation goes further than functional separation. It involves the separation of a vertically integrated firm not only operationally but also in terms of ownership, into: a company owning the local access network,[69] providing wholesale access (the network operator); and the rest of the company that provides retail services. The separation of ownership is intended to eliminate the incumbent's incentives to discriminate.

The potential benefits of structural separation, in the regulation of vertically integrated incumbent operators are said to include:

- Installing sustained incentives for the dominant operator to provide non-discriminatory (equivalent) access to its networks.
- Promoting access to the incumbent's network, thereby promoting innovation, either by new entrants or by the incumbent.
- Creating a "level playing field" since the incumbent's retail arm would now deal with the wholesale access provider without preferential treatment.
- Eliminating any conflict of interest between the incumbent's wholesale and retail divisions e.g., in terms of pricing and marketing (since the wholesale network division would now be guided by its own commercial interests, rather than the interests of its retail division).
- Enabling a regulator to focus on the wholesale network, to more effectively regulate the service quality, network reliability, and access to essential network facilities; and

- Improved transparency and monitoring that can help in eliminating cross-subsidisation between the incumbent's networks and retail divisions.

There are also a number of potential costs of structural separation. Splitting up an integrated operator is likely to be a costly and difficult process, for instance, in regard to where to draw the dividing line. It may be difficult to determine at which level in the network hierarchy the separation should be made. To add to this problem, the appropriate boundary of separation might change over time *e.g.*, due to the development of new technologies and competitors' networks.

Separating a vertically integrated operator eliminates or reduces co-ordination benefits, as well as the economies of scale and scope, that derive from vertical integration. Consequently, for instance, it may lead to higher costs and delays in investments. For example, co–ordinating investments in the network between the new (separated) parties may become more of a problem because innovation in services may require investments in competitive as well as non-competitive activities. There are concerns over whether there would be adequate investment in network infrastructure when providers are separated from the direct revenue and consequent incentives that flow from vertical integration. This problem could be significant in the communication industry where technological change is rapid and where investment demands are pressing.

Problems of co–ordinating investment between wholesale and retail operators could also impede investment and innovation. If considerable, these problems could serve to delay fibre deployment. Moreover, separation can underpin market power in the access market and this may deter the rollout of alternative networks. Furthermore, while structural separation reduces an integrated operator's scope to raise rivals' costs, it can increase, for example, an incumbent's costs since separation is costly and time-consuming. In particular, an incumbent would face the costs of re–organisation, although it is difficult to say how substantial these costs would be.

Another cost increase could result from a separated firm having a higher cost of attracting funds than an integrated firm. Regulation to prevent monopoly pricing would remain necessary even after structural separation of the local loop. Where there is structural separation, the operator of the NGA needs to have adequate incentives to upgrade networks. Thus, structural separation of an established operator should be embarked upon only after careful assessment. To add to the difficulty in doing so, at this stage only theoretical arguments can be examined because there is not yet a case where vertical structural separation of a telecommunication operator has occurred, and hence no empirical evidence is accessible.

4.4 Operational, functional and structural separation

Experience is beginning to be accumulated among those OECD countries that have introduced operational or functional separation. In two OECD countries, Australia and New Zealand, incumbent telecommunication operators have proposed structural separation to take place in 2011.

Australia

Telstra, the Australian incumbent telecommunication operator, had an operational separation plan (OSP) approved by the government in 2006. The company was directed to achieve operational separation, equivalence and transparency. Under the OSP, Telstra was to maintain three business units, wholesale, retail and "key network". It was to operate these businesses 'substantially separate' from each other.[70] The operational separation arrangements that applied to Telstra were considered ineffective. In June 2008, the ACCC noted, in relation to the effectiveness of Telstra's Operational Separation, that it continued to receive complaints of conduct that suggest that equivalence, which was the objective of the regime, was not being achieved.[71]

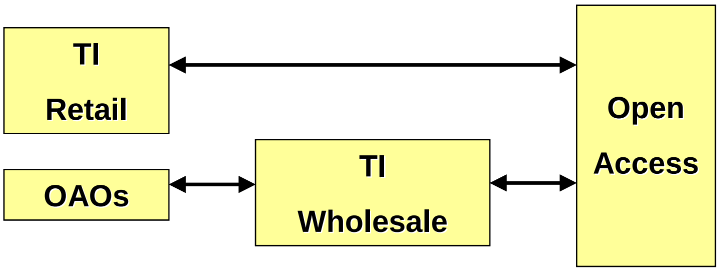
The ACCC argued that structural separation of Telstra was the only framework that would ensure equivalence in access during the transition phase to Australia's proposed National Broadband Network (NBN) and was the only form of separation consistent with the type of wholesale– retail market structure envisaged for the future NBN environment. As part of an USD 11 billion financial arrangement with the government, Telstra has reportedly agreed to the structural separation of its fixed wholesale and retail services which, it says, is in the interests of its shareholders as the NBN proceeds.[72]

Italy

In July 2008, the incumbent, Telecom Italia (TI), proposed to the Italian NRA AGCOM a set of Undertakings aimed at enforcing the existing obligations imposed in 2002, intended to ensure non-discrimination in the provision of wholesale access network services. According to AGCOM, Telecom Italia proposed the Undertakings: "… to avoid potential sanctions resulting from its pending disputes with AGCOM and alternative operators…".[73] In particular, Telecom Italia created the "Open Access" unit to provide services of an equivalent type and quality to its own retail and wholesale services units, which in turn interface with their retail customers and competitive providers.

The new unit is in charge of the passive elements of the copper and fibre access network and of the local backhaul network (copper and fibre). Telecom Italia's wholesale division continues to act as a "one-stop-shop" providing all wholesale services, including access network services such as local loop unbundling, to alternative operators. In this way, Open Access receives orders for access network services from both the company's Wholesale (which serves alternative operators) and Telecom Italia Retail (Figure 4.1).

Figure 4.1 Telecom Italia's Functional Separation



New Zealand

In March 2008, Telecom New Zealand's plan for functional separation was approved by the government. The main features included:

- The separation of Telecom New Zealand into separate Access Network Services, Wholesale and Retail business units (a 3-way split).
- A requirement for Access Network Services to be operated on a stand-alone basis and for Telecom Wholesale to be operated at arm's-length from any retail business units.
- The establishment of an Independent Oversight Group, backed up by Commerce Commission enforcement, to ensure Telecom New Zealand faithfully implements the Separation Plan.
- A requirement that relevant products, especially LLU and bitstream services, are available to all market participants on equivalent terms.

The core principle that separation aims to achieve is equivalence of access to bottleneck facilities[74] overseen by an independent oversight board. One of the main differences, to the approach to functional separation in the United Kingdom, was that the relevant products include LLU and bitstream access services and future fibre-based products, but do not include PSTN legacy services. The regulatory focus is on accelerating the roll-out of NGA, towards which end the government made available public funds of USD 1.2 billion, managed through a public-private structure. In August 2010, Telecom New Zealand announced its intention to structurally separate its network division (Chorus2) in order to participate in the rollout of New Zealand's proposed NGA, having already undertaken an operational separation (Chorus1).

Sweden

In 2006, the National Post and Telecom Agency (PTS) was directed by the Swedish Government to investigate the preconditions for the separation of a vertically integrated telecommunications operator. PTS considered functional separation as well as full structural separation and concluded that it should have the mandate to impose functional separation in order to be able to solve competition problems in the Swedish market. Faced with the introduction of more robust regulatory remedies, TeliaSonera, the incumbent telecommunication operator, announced voluntary measures for the purpose of separating its access network, creating 'Skanova' in January 2008 to provide wholesale access service to alternative operators and its own retail business unit.

TeliaSonera established an independent overseeing body. In addition to TeliaSonera's voluntary establishment of Skanova, the Swedish government introduced legislation that came into effect in July2008, empowering PTS to impose functional separation on the incumbent as a last resort. PTS was also given the right to accept voluntary separation measures introduced by the incumbent.

United Kingdom

Following an assessment of the first two decades of telecommunication regulation in the United Kingdom, Ofcom determined that the prospects for competition in the broadband market were insufficient to meet the objectives set by the government.[75] Ofcom canvassed the structural separation of BT, the incumbent telecommunication operator, and considered recommending an investigation by the United Kingdom Competition Commission under the provisions of the Enterprise Act 2002. This could have resulted in structural separation for BT. Ofcom noted:

> "*Such an investigation would be wide-ranging. The Competition Commission would be able to impose structural remedies. It could, for instance, examine whether the only solution to the problem of*

inequality of access would be the separation of BT's wholesale network operations and its retail service provision." [76]

Faced with the prospect of structural separation, in June 2005, BT offered Ofcom a set of 'Undertakings' *in lieu* of Ofcom making a reference to the Competition Commission. These Undertakings resulted in the functional separation of BT's access and service divisions and the establishment of Openreach.[77] The cornerstone measure was "Equivalence of Inputs" (EoI), whereby both BT and external customers of Openreach use the same ordering systems, are offered the same prices, terms and conditions and have access to the same sets of services and commercial information. To help ensure real equality of access, a number of different measures were put in place, including the establishment of the "Equality of Access Board" to oversee Openreach's operations, the introduction of a detailed code of practice to be followed by all employees,[78] and several organisational changes aimed at ensuring separation between Openreach and BT. In its Annual Report for 2010, the Equality of Access Board concluded that Openreach has complied with its Undertakings but that breaches have occurred, including 11 non-trivial breaches of the Undertakings.[79]

Ofcom has undertaken a number of impact reviews following BT's functional separation. The assessments have been mixed. Although competitive operators were satisfied with outcomes overall, they also expressed complaints.[80]

United States

In the United States, the courts and the Federal Communications Commission (FCC) have employed separation as a means of constraining the market power of dominant telecommunication operators. Best known is the 1984 divestiture of AT&T, breaking it up into a competitive long distance carrier and seven Regional Bell Operating Companies (RBOCs) with franchises over local access markets but prohibited from offering long distance services. In 1996, a new Telecommunications Act was introduced. The goal of this new law was to let anyone enter any communications business and to let any communications business compete in any market against any other.

The 1996 Act required that the RBOCs open their local networks to competition prior to receiving authorisation to provide in-region long distance services. That Act also required that, after receiving such authorisation, the RBOCs provide those services only through structurally separate affiliates for at least three years. The United States separation referred to was a 'horizontal' separation of local from long distance rather than the 'vertical' separation of wholesale from retail networks that is the relevant issue in an NGA environment and the focus of this report.

4.5 Cost-benefit analysis operational, functional and structural separation

Consideration of structural separation should be subject to a cost-benefit analysis. This would accord with the OECD's 2001 Recommendation that it reaffirmed in 2006. The same could be said for policy makers considering operational/functional separation or pursuing vertically integrated competition. A cost-benefit analysis of structural separation would, however, not be easy to conduct nor is it likely to reach a straight forward result. As there is no actual example of structural separation, the benefits and costs are even more conjectural. Certainly, any assessment will inevitably involve a range of assumptions and estimates *e.g.*, on expected efficiencies or costs, such that the final decision will inevitably be a matter of judgement.

The benefits that flow from functional or structural separation are associated with the improvements to competition that accrue resulting from implementation of the separation. As many of such benefits flowing from an increase in competition are prospective, they are difficult to ascertain at the time the policy is being considered or implemented. That is, the benefits expected to accrue would be higher, the greater the present and expected costs of anti-competitive discriminatory behaviour. The corollary is that functional or structural separation measures are a more justifiable regulatory measure in markets with low infrastructure competition and high (or prospectively high) anti-competitive discriminatory conduct, because in this case, the costs of discrimination are more likely to exceed the costs of implementing these measures. If public investment is used as a tool to shape market structures, valuing the "opportunity cost" of such expenditure needs to be considered and this too will not be easy.

Nonetheless, a cost-benefit analysis will ensure a systematic identification and evaluation of important positive and negative impacts. This will help ensure increased transparency, especially of assumptions involved when sensitivity tests are conducted on important items of cost and benefits.

4.6 Separation and regulatory tools

The recent establishment of functional separation as a remedy within the amended European framework for electronic communication has focused attention not only on functional separation but also on structural separation.[81] Notably, thus far, all existing examples of voluntary agreement by incumbents (Australia, Italy,[82] New Zealand, Sweden, the United Kingdom) has actually been implemented under financial inducements or prior to proposed actions by governments that would in some way directly shape future market structure.[83] For example, in the case of Australia, there was a non-binding commercial agreement between the company that is rolling out the National Broadband Network and the incumbent to structurally separate. In the case of New Zealand, an integrated incumbent would not have been able to tender for public funding to build the proposed NGA.

It was the proposal by Ofcom to refer BT to the United Kingdom Competition Commission and the prospect that it (the Competition Commission) would mandate structural separation that influenced the operator to propose the "Undertakings" contained in BT's functional separation. This not only influenced the incumbent's willingness to functionally separate in 2006, but no doubt continues to influence BT's conduct as a functionally separated operator.

This suggests that the effectiveness of functional separation and, indeed, *ex ante* access measures, would be enhanced if it could be backed up with a credible threat that if access regulation and/or functional separation is judged to have failed, there is a prospect that the anti-competitive operator could be structurally separated. It would be "incentive compatible" in providing a strong incentive for access providers to make functional separation or, indeed, *ex ante* access regulation work rather than face the prospect of being structurally separated.

This suggests that structural separation should be in the government's toolkit. The experience with functional separation and also previously with various versions of accounting and 'operational' separation suggests that *ownership* separation may sometimes be required to effect the change in incentives that would achieve the critically important aim of – "the equivalent treatment of all access seekers". This conclusion goes further than the European Commission's Recommendation wherein functional separation constitutes the exceptional remedy of last resort. If this approach were adopted *structural* separation would be available as the last resort remedy. Any inclusion in regulatory toolkits should be carefully considered, in each country, in relation to any changes this may necessitate in legal frameworks and the implications this could have for incentives in relation to investment and innovation.

There are persuasive reasons why the power to structurally separate a vertically integrated operator should be conferred under *ex post* Competition Law rather than under *ex ante* sector specific legislation. Structural separation or the divestiture of business divisions is already commonly provided for in Competition Law as a remedy to rectify anti-competitive conduct such as the abuse of a dominant position.

If functional separation fails to have the desired effect *e.g.* of "equivalence of inputs", then the matter could be referred to the Competition Law authority which would have the power to mandate structural separation. This would be consistent with arguments that with "convergence", telecommunication operators should be treated like operators in other enterprises. It would also be consistent with the position that the longer term aim should be to progressively reduce *ex ante* sector specific rules as competition in the markets develops and, ultimately, for communications to be governed by competition law only.[84]

4.7. Some countries that considered but decided against functional or structural separation

A number of national regulators have considered but rejected the use of separation as a regulatory remedy. For example, some regulators opposing structural separation (*e.g.* France, the Netherlands and Germany) emphasise the high costs of implementation; the irreversibility of this measure; the potential distortion of investment; the loss of efficiencies accruing through vertical integration; and the temporary decrease of service quality caused by major changes within the incumbent's organisation.[85] For instance, in France, ARCEP, the French regulator, has raised concerns about functional separation on the grounds of the significant costs associated with implementation and the loss of efficiencies accruing through vertical integration.[86]

In the Netherlands, OPTA, the regulator, decided against the imposition of functional separation for KPN on the basis of the existence of competition from alternative infrastructure operators, especially cable which has extensive coverage but also municipal networks. Moreover, KPN was considered to be already investing strongly in NGA. Thus functional separation was considered less necessary and not proportionate in the Netherlands in terms of the costs involved in relation to what it could achieve.

In Germany, the government's view is that because its influence on investment incentives is unclear, structural separation should be predominantly regarded as a means to resolve problems related to competition rather than a means of stimulating investment. On the one hand, it may very well be that it can eliminate some of the strategic incentives (especially of the incumbent) which today impede investment, but on the other hand it would pose a severe disruption to current investment plans of market players, fuel expectations that the newly created infrastructure entity will embark on a nationwide rollout and thus increase uncertainty which further delays investment by others.[87]

The conclusion which can be drawn is that there is no unanimous support for functional separation, let alone structural separation.[88] The initial question to be posed in relation to NGAs, however, is whether regulatory authorities should have the power to mandate structural separation should there be compelling evidence, including a persuasive cost-benefit analysis, that justifies it.

4.8. Prospective structural separation

Another more recent dimension of the structural separation debate is whether NGA creates a welcome opportunity to *prospectively* install a structurally separated framework. A number of countries have decided that it does.

Australia

The Australian Government say it's National Broadband Network (NBN) policy addresses fundamental structural issues in the Australian telecommunication sector. The sector has been characterised by high prices and a lack of investment in fixed-line high-speed broadband infrastructure. This has been attributed to the market dominance of the former incumbent, Telstra. Telstra's high degree of horizontal and vertical integration has hindered the development of competition and provided it with the incentive and ability to favour its own retail operations over those of its competitors, who need to access

Telstra's networks to supply services. To address this issue, the National Broadband Network, NBN Co, will be a wholesale only operator providing open and equivalent access to all retail providers. As a wholesale-only operator, NBN Co will not have incentives to restrict access, but to maximise the number of retail providers that use its networks. It will not have a formal monopoly, in deploying fibre access networks; investment from competing providers is permitted, and the Government is not preventing competitors from entering or operating in the industry. However, the high cost of laying the fibre, the long asset life of fibre and the limited ability to differentiate fibre confers upon NBN Co the characteristics of a natural, stable infrastructure monopoly (analogous to an electricity grid or gas pipes). It is not expected that it would be economic for a competitor to replicate the network on a national basis.

Although it does not have a monopoly, as the owner and operator of the major fixed-line high-speed national broadband network, NBN Co will have significant market power. To guard against incentives to abuse that power, the Australian Government has introduced legislation into the Parliament that will limit and focus NBN Co to wholesale telecommunications and require it to provide access seekers with open and equivalent access to services, subject to strict oversight by the competition regulator, the ACCC. The legislation also makes provision for functional separation and the divestiture of assets.

The Australian Government's policy is that NBN Co must connect 93% of premises to its fibre networks, and provide next generation wireless or satellite broadband to remaining premises. The Government also has a policy of uniform national wholesale pricing on the National Broadband Network.

New Zealand

In September 2009, New Zealand announced the development of a National Broadband Network. The NGA will be a FTTP network aiming to reach 75% of households within 10 years. The government would invest up to USD 1 billion in open-access fibre infrastructure to accelerate the roll-out of the network offering downlink capacity of 100 Mbit/s and uplink speeds of at least 50 Mbit/s. A new government-owned investment company ("Crown Fibre Holdings") has been established to carry out the government's partner selection process and manage public investment in the fibre networks.

Crown Fibre Holdings and each partner will establish commercial vehicles, a "Local Fibre Company" (LFC), to deploy fibre network infrastructure and provide access to dark fibre products and, optionally, certain active wholesale Layer 2 services. Tenders for the geographical areas covered by the network are to be issued for private sector participation in network construction, including the link between the dark fibre backbone and individual premises. A broad array of firms are seeking these contracts, including electricity providers and Telecom New Zealand. The latter has proposed structural separation to be able to participate.

Singapore

In Singapore, policy makers decided that the publicly co-funded national broadband network should have three distinct layers:

- The 'Retail Services Providers' (RSP) layer comprising multiple small and large service providers competing to provide retail broadband-based services to businesses and consumers.
- The 'Operating Company' (OpCo) layer, made up of a handful of operators installing active infrastructure such as routers and switches to provide wholesale bandwidth services to the RSPs.
- The 'Network Company' (NetCo) layer, made up of only a single operator (which they decided was necessary given the high capital investments and significant economies of scale required to be viable), which is laying the passive infrastructure to all homes and businesses and leasing the infrastructure to OpCos.

The regulator has imposed functional separation between the operational company, OpCo, the company that controls the active elements of the new broadband network because it says:

- The active network is relatively easier to duplicate by deploying equipment only rather than infrastructure.
- A full coverage in active network can be achieved as long as a nation-wide passive network is available.
- A variety of choices in service scope / technologies on active network can be provided.

Should another operator build out a FTTH network similar to that built out by NetCo or OpCo, the regulator would consider regulating that operator in a similar manner to the regulation of NetCo and OpCo.

The Singapore government is providing grants of up to USD 543 million for the Next Gen NBN NetCo, and USD 181 million for the Next Gen NBN OpCo, respectively. In 2008, the OpenNet Consortium, formed by Axia NetMedia from Canada, SingTel, Singapore Press Holdings, and SP Telecommunications, was awarded the contract as the NetCo to construct the passive infrastructure. OpenNet aims to achieve its target of 95% coverage by mid-2012. Starting from 2013, OpenNet will be responsible for connecting fibre to households and business premises on request.

The price of fibre connection by OpenNet and the wholesale price by Nucleus Connect are regulated but the final prices for end users will be set by the RSPs. Singapore's Next Gen Nationwide Broadband Network (NGNBN) officially began commercial operations in September 2010.[89]

Other countries

The relatively recent course chosen by Australia, New Zealand and Singapore, in respect to NGAs, has not yet been adopted by other countries. Similar elements of these plans, however, are evident in recent proposals for public investment in national or regional backbone networks. In Chile (and several of its South American neighbours: Argentina[90] and Columbia[91]), governments are establishing or investing in separate wholesale suppliers of backhaul service. The government in these countries may feel that a new separated operator can deliver many of the benefits and might be more feasible than splitting up an established operator.

Public investment in access networks as well as "open" backbone networks poses regulatory issues. The incentives for access operators, or a new backbone operator, to invest on an ongoing basis, will still need to be addressed as will any monopoly power resulting from the intervention.

There are also concerns about the loss of benefits from vertical integration. The evidence on such benefits and costs is mixed and not compelling *a priori*. For instance, some have argued that the benefits from structural separation outweigh the costs, and that the estimated costs due to lack of co-ordination and the disincentive to invest and innovate are largely exaggerated.[92]

SECTION 5. APPROACHES TO NGA MARKET STRUCTURE, ACCESS AND DEVELOPMENT

5.1 Non-commercial areas, market structure and the role of government subsidies

A number of governments have announced or committed funds as part of encouraging investment in and supporting transition to next generation broadband networks.[93]

Municipal investments

In a number of countries local governments have been involved in the deployment of broadband facilities. Several of Sweden's municipalities, for example, have been involved in some form of public support for broadband deployment.[94] The basic model used is that the municipality builds passive capacity, or dark fibre, through operator-neutral public tenders designed for constructing the capacity. The dark fibre is then leased out to private providers who then compete on services and electronics. The model is applied both in major cities, like Stockholm, as well as in smaller towns.

Amsterdam's Citynet is a notable municipal (public-private partnership called Glasvezlenet Amsterdam or GNA) project aimed at providing a FTTH network throughout the city.[95] The network is a point-to-point fibre network connecting about 10 000 households directly, each by its own fibres (2 per household), to each point of presence (POP). The original project setup was modified in late 2009 as a result of the change in ownership in one of its shareholders (Reggefiber, 42% of its shares now held by KPN) and the decision of KPN to enter into a partnership with the Citynet project to expand its FTTH services in Amsterdam. The Dutch competition authority (NMa) and the telecom regulator (OPTA) have imposed as a condition for these changes in ownership a regulation on KPN, Reggefiber and GNA to offer identical non-discriminatory, price-limited access to both the POP's and unbundled fibre lines for all fibre projects where Reggefiber has a majority share, effectively standardising the architecture in the Netherlands to unbundled point-to-point FTTH as one of the first regulators to do so.

The original business model and project setup is described first, followed by the modifications implemented in 2009/2010. The business model was separated into three distinct layers. The first layer is called the "passive network infrastructure" that includes ducts and direct burial cable, fibre, the Fiber Termination Unit inside each individual apartment and the POP including the Optical Distribution Frame (ODF), patch cables, 19 inch racks and air-conditioning. The second layer is the active wholesale layer that includes network management, control, and maintenance systems such as switches, routers and EDFA's for RF overlays[96] It was managed and maintained by a wholesale network operator that won a concession from GNA. The third layer is the retail layer, consisting of providers who buy capacity, on a non-discriminatory basis, from the two lower layers, and provide retail services to customers. They would each invest in their own service platform: equipment, services, and billing/customer care.

The first, passive layer, was owned by a partnership called Glasvezelnet Amsterdam (GNA) comprising: the City of Amsterdam, with a one-third share; five social housing corporations (a non-profit model of housing ownership of apartment buildings), which owned a one-third share of GNA; and the remaining third was equally divided in two one-sixth shares between two for-profit investors, ING real-estate, a subsidiary of ING, and Reggefiber, a Dutch company whose business it has been to build open fibre networks. The shares reflected the actual share of investments made by each of the parties in the EUR18 million equity investment of the USD 42 million project. GNA issued a tender to construct passive networks to dig and construct the ducts, and pull the fibre. This tender was issued to construction companies, and GNA retained ownership over the ducts, fibre and cabinets. GNA also issued a public tender for the concession to operate the wholesale layer. The contract was awarded to a subsidiary of Telecom Italia, BBned. BBned was to invest in active wholesale layer components, which it would then own and operate while also operating, but not owning, the passive layer. The contract required BBned to remit fees per connected household to GNA, and to sell wholesale access services to third party service providers on an open access, non-discriminatory basis. These retail providers would sell services to end users and pay fees. BBned itself had retail affiliates that would sell such services.

Dutch, Spanish, and Swedish cable operators UPC, ONO, and Com Hem, as well as France Telecom, intervened to try to persuade the European Commission that the public investment by the municipality of Amsterdam was illegal state aid, that it would undermine market provisioning and that, unlike in smaller and more remote municipalities, the investment was unjustified in an urban centre already served by commercial operators. [97]

One type of public investment that is not considered state-aid is where the state invests on terms that would have been reasonable for a commercial market investor. Factors that helped persuade the EC that Amsterdam's investment in GNA was the sort of investment that a private company might have made included:

- The co-investment by two private companies, on equal terms, one a real-estate development firm that had plausible reason to invest in improving the broadband infrastructure of its real estate holdings and the other a company specializing in open fibre infrastructure.
- The fact that the investment was in passive elements, which were expected to last for thirty years and therefore could be sustained with the relatively lower rates of return expected by GNA.
- The fact that the City of Amsterdam was to be reimbursed all of its pre-project investments, with interest, as part of the project costs, all of which were ultimately intended to be paid from user fees paid by the wholesale users, and ultimately the retail subscribers; and
- an independent review of the business plan.

As a result of the changes in ownership and regulatory requirements, implemented in late 2009, the structure and business model have been slightly modified. The City of Amsterdam and five social housing corporations now own a one-third share of GNA and the remaining part is owned by Reggefiber. The obligation to offer unbundled access to all operators means that multiple operators now can put their equipment in POP’s and offer services to customers and that the exclusive concession to BBned has been terminated. Operationally GNA is now more integrated into the larger open fibre network operation of Reggefiber, as Reggefiber is now obliged by the regulators to integrate the commercial offering of all fibre projects (including GNA) to all operators.

After the conclusion of the discussions with the NMa and OPTA, GNA/Reggefiber have resumed the buildout beyond the initial 40.000 households. The commercial offerings of KPN of FTTH-based services have been tested in 2009 and 2010, and have been introduced in Amsterdam next to the existing service providers.

European Commission guidelines on public aid to NGA

In part as a result of the Dutch experience and experience elsewhere (*e.g*., Sweden) and in part in response to the new wave of stimulus investments, the European Commission deliberated the issue of state aid to broadband deployment more generally and published its final decision in September 2009.[98] The objective of the Commission's state-aid control provisions is to ensure that government interventions do not distort competition and intra European Community trade. The provisions specify formal guidelines for differentiating, by market structure/market contestability conditions, between white (unserved) areas, grey (private monopoly served) areas and black (multiple private infrastructures) areas for NGA networks. As a general rule, public funding is acceptable for white areas, possibly acceptable in grey areas, and not allowed in black areas.[99] Any public intervention seeking to support the provision or acceleration of NGA network deployment must ensure that it is compatible with the public funding rules.

White NGA areas: support for NGA network deployment in under-served areas

As with basic broadband services, subject to a set of conditions that should be met by Member States, the European Commission will consider as being compatible with the State aid rules measures that support the deployment of NGA networks in areas where no broadband infrastructure currently exists or for areas where existing broadband operators consider it unprofitable to deploy NGA networks. In white NGA areas where one basic broadband network already exist (traditional grey area), the grant of aid for NGA networks is subject to the demonstration by the Member State concerned that the broadband services provided over the networks are insufficient; and that there are no less distortive means (including ex ante regulation) to reach the stated goals.

Grey NGA areas: need for a more detailed analysis

A grey NGA area may be in an area where *a*) there is no other basic broadband infrastructure besides the NGA; *b*) as well as in an area where one or more basic broadband providers are also present. In areas where one private investor has already deployed a NGA network or may be in the process of deploying it in the next three years and there are no plans by any private investor to deploy a second NGA network in the coming three years. In the context of its detailed assessment, the European Commission would assess whether: *a*) the overall market conditions are not adequate, by looking, *inter alia*, into the level of current NGA broadband prices, the type and conditions of services offered to residential and business users and whether there exists, or is likely to appear, demand for new services that cannot be met by the existing NGA network; *b*) in the absence of *ex ante* regulation imposed by a NRA, effective network access is not offered to third parties or access conditions are not conducive to effective competition; c) overall entry barriers preclude potential entry by other NGA network investors; *d*) the NGA network already in place was built on the basis of a privileged use/access to ducts not accessible by or not shared with other network operators; *e*) any measures taken or remedies imposed by the regulatory authority with regard to the existing network provider have not been able to overcome the problems.

Black NGA areas: no need for State intervention

In areas where there already exists more than one NGA network or private investors may be in the process of deploying competing NGA networks, the Commission will consider that state support for an additional publicly-funded, competing NGA network is likely to seriously distort competition and is incompatible with the State aid rules.

5.2 Various country approaches to NGA market structure, access and development

In this section and the next, the various approaches adopted in different countries are discussed and an attempt is made to classify the approaches into a number of categories. However, features in a country's approach may not allow it to be slotted neatly into a single category and overlap is common.

The increasing involvement of some countries has prompted debate over the appropriate role of government in the deployment of high speed broadband. As noted earlier, the current European Union strategy is to depend fundamentally on market forces to determine NGA rollout and take-up. Typical of the view of European Union Member States (and of the European Commission itself) is that the market structure of telecommunications supply in a NGA environment is as yet unpredictable and that the market should be kept contestable. For instance, Germany's expressed view is that:

> *"The link between market structure and NGA investment is a complex one. From the current point of view, it is impossible to predict how the described factors will eventually play out in terms of market structure and infrastructure availability. From the German experience the only thing that can be considered certain is that a sufficient level of competition and openness to market entry is highly conducive to NGA investment. However, whether a market structure with a large number of "regional incumbents" or instead a situation of an oligopoly with several nationwide players results in more investment, and which of these two will eventually emerge, is so far indeterminate."*[100]

Other countries, such as Australia, Chile, New Zealand and Singapore consider that significant government involvement and funding is necessary. Some countries (*e.g.*, France, Germany, the United States) are concerned with addressing "digital divides" including disadvantaged rural and remote areas. In the United States, these are explicit goals stated in the National Broadband Plan. Most countries are concerned with "universal service" in the longer term although at this stage this aspiration is confined to basic broadband (e.g., Finland, United Kingdom) rather than high-speed broadband.

An examination of the various approaches taken by different countries thus far leads to one clear conclusion: "One size does not fit all." In the United States and Europe, the policy focus has been to create a framework that facilitates and encourages private investment. There has been a relatively limited range of subsidies on the supply side, although some subsidy programmes on a small to medium scale exist. In some Asian countries such as Japan and Singapore there has been relatively more focus on government intervention and funding NGAs. Some governments *e.g*., Australia and New Zealand, have not been confident that the private sector would invest enough, fast enough and in all the desired locations, and have decided to make available government funds in order to directly deploy next generation broadband networks. In Australia, and to some extent in Singapore and New Zealand, the government made a decision to place deployment of NGA high on the political agenda. Some concerns have been raised. For instance, the Australian approach has been said to be a re-introduction of the former government-owned monopoly model that prevailed worldwide until the 1990s as it is based on the NBN Co supplying both passive and active infrastructure. However, it is not a vertically integrated monopoly over networks, operation and services as in the past.

An examination of various approaches suggests measures that have been successfully used. For instance, in France and the Netherlands, it appears that access regulation such as local loop unbundling was successfully applied. The lesson from experience in the United Kingdom is that, to some extent, functional separation can be successfully applied.[101] And municipal provision of broadband networks has had a measure of success in countries like Sweden and the Netherlands. However, measures/experiences may not be transferable from one location to another since there are significant differences in economic, social, geographic and political circumstances between countries.

5.3 Categorising approaches to NGA market structure, access and deployment

Countries are responding differently influenced by differing goals and circumstances but the approaches taken by policy makers and regulators might be broadly classified into the following categories.

Primary reliance on market forces for NGAs

Market forces are primarily relied upon to determine the development of NGA because investment in fibre networks by incumbent operators is occurring in a competitive environment and therefore to sustain incentives for new investment it should not be subject to *ex ante* regulation. Competition would develop further as new entrants also invest in fibre NGA or alternative network infrastructures capable of delivering NGA functionality.

In the United States, competition among separate physical platforms is further developing in the market for broadband connections to end users.[102] Alternative platform providers include cable companies and wireline telecommunications operators (which currently are the two most significant service providers) as well as mobile wireless 3G service providers and providers of other technologies such as fixed wireless. Availability, price and quality affect the competitive impact of the alternative platforms but cable, where it provides broadband services, has had the largest competitive impact. In view of these market conditions in the United States, the FCC has eliminated or forborne from (*i.e.,* abstained from enforcing) imposing access obligations that could deter investment in next-generation broadband platforms.

Not all countries have the same breadth of alternative infrastructure in place as the United States, however, so these policies may not be equally applicable in other countries. Moreover the United States has examples of municipal networks and the market itself driving new developments in wholesale services provision (*e.g*. Lightsquared, Wireless networks providing competitive wholesale services to Machine to Machine – M2M – services). In addition, the United States is using public funding in rural areas to promote the expansion of broadband availability and upgrading existing facilities. Some locations, of course, like Hong Kong, China, have a population density which means that they do not need to apply public funding to face such challenges and can rely entirely on the market and the city of Hong Kong itself has some of the fastest most inexpensive broadband access in the world and now forbears from *ex ante* access regulation.

Some OECD countries, such as Korea, have achieved excellent results for NGA development from infrastructure competition in their urban areas. Yet even in these countries, providing NGA competition in rural areas is a significant challenge. In addition, the role of other policies that have increased broadband access competition, such as local loop unbundling in countries such as France and Japan, needs to be considered. In many countries, it may be challenging to get one NGA to all areas of the country, let alone facilities-based competition. This is one reason why some countries have opted for functional separation and others have plans for national broadband networks with separate provision of wholesale services mandated to cover (almost) all regions, including those that are relatively commercially unattractive.

Switzerland has taken a substantially different approach to other countries that have performed well in regard to broadband deployment. Switzerland relied primarily on inter-platform competition between the incumbent telecommunications company, that offers DSL, and cable companies. Notably, unlike the majority of its European neighbours, Switzerland does not impose local loop unbundling. The modification of the Telecommunications Act (TCA), which entered into force in 2007, provides this measure, but it is limited to twisted metallic pairs, *i.e*. the legacy network of the historic operator. Moreover, Switzerland applies an *ex-post* system. That means that the regulator (ComCom) lays down the conditions for access to the equipment and services of the provider which is dominant in the relevant market only if the players in the market have not been able to agree within the statutory framework and one party applies for regulation. Further information on the Swiss experience, including a proposed strategy for multi-fibre infrastructure, can be found in the Annex to this report.

Determine where bottlenecks are and take action through access regulation

Many incumbents in the communication market still have market power which arises from their former monopoly position so that, even though investment in fibre networks is "new", incumbents are still leveraging their historical market power and there is a risk that, if exempt from regulation, such investment would result in the creation of new dominant positions. Under this scenario regulators would maintain *ex ante* regulation and be proactive by identifying potential bottlenecks where regulatory action is required. Most OECD countries are in this category.

Construction costs (civil engineering costs) are estimated at around 60-80% of total costs in rolling out a FTTH network and constitute a large percentage of total network costs. Incumbents have a significant advantage because their historical monopoly position has given them existing rights of way and ownership of the ducts used by copper networks (which often means they do not pay for rights of way). In this context, countries are recognizing[103] that the main *ex ante* regulations needed to reduce bottlenecks include:

- Ensuring access to rights of way, at reasonable prices, for new entrants and incumbents.
- Ensuring access by new entrants to existing ducts/poles of both network operators and utility companies and municipalities.
- Regulations to ensure the sharing of access to the inside wiring of apartment buildings and homes.
- Facilitating access to street cabinets and collocation in street cabinets. Regulators need to work with municipalities to find solutions to avoid excessive duplication of street cabinets and/or restrictions on investing in street cabinets by new entrants.
- Municipal networks playing an important role in enhancing competition in fibre networks. If these develop governments should encourage them to be open networks, that is providing dark fibre to service providers rather than becoming themselves service providers. Nor should the existence of a municipal network providing dark fibre mean that investment in other fibre networks in that municipality should be prevented.
- Where mandated, ensuring wholesale broadband access is provided on a non-discriminatory basis which must ensure that the quality of service provided to wholesale service providers is the same as that of the owner and operator of the network.
- Where adequate facilities-based alternatives do not exist, consider applying local loop unbundling policies to new fibre networks, in particular sub-loop unbundling since with certain fibre configurations (Fibre-to-the-Node) new entrants will need access to street cabinets.

Establishing targeted time frames for various steps of the rights of way process helps in providing predictability to the applicant. In order to facilitate competing fibre local loops, reduce costs and the need for multiple excavation and other civil works in municipalities, the sharing of existing ducts, both of telecommunication and cable companies, but also of other utilities, are important policy requirements. Similarly access to buildings and sharing of in-building wiring is important to ensure effective competition.

Develop end to end infrastructure competition through LLU but without imposition of functional or structural separation

France, the Netherlands, Germany, Spain, and Ireland are examples of this approach. In this context, the first requirement is to define what *ex ante* regulation means in the context of the roll-out of fibre networks. For instance, maintaining unbundling as the cornerstone of regulation is not helpful if, for technical and/or economic reasons, unbundling is not possible. To enhance prospects for competition, the French regulator has advocated the provision of multi-fibre whether fibre is deployed through point-to-point or point to-multipoint technology as has the European Commission[104]. In Switzerland, Swisscom already uses multi-fibre. Ofcom has advocated the use of Virtual Unbundled Local Access (VULA) and Physical Infrastructure Access (PIA).[105]

Access regulation plus functional separation

A question that regulators have begun to consider is how to achieve competition in the next generation access market if facilities-based competition does not occur and a single operator becomes dominant in the market. One remedy under consideration is the possibility of implementing either functional or structural separation of the fibre local loop from the NGN application and service level. The European Commission (2009) has installed the power to implement functional separation as part of the regulator's toolkit and some European Union countries have been actively considering this remedy following the United Kingdom's initiative to functionally separate BT in 2006. In the United Kingdom, Sweden, Italy and New Zealand, the functional separation of the dominant incumbent has been imposed to complement LLU. This report suggests that the power to impose structural separation may need to be considered for addition as part of the regulator's toolkit. Moreover, NGA presents a real opportunity to install *prospectively* a new structurally separate fibre local loop as Singapore has done and as Australia and New Zealand propose to do.

Facilitate deployment of a wholesale backbone network

In Chile, the government will facilitate the deployment of a new wholesale backbone network. Some stakeholders have proposed a similar arrangement in Italy but through a public-private partnership. The Argentinean government is reportedly planning to set up a state-owned telecommunications company to offer wholesale services, using capacity and the infrastructure of state enterprise "Arsat" (Satellite Solutions Company of Argentina).[106] According to the report, the government's plans include deployment of a national fibre backbone.

Such co-investment arrangements are a relatively new development in the telecommunication sector. The arrangements can be private-private, or private-public, vertical or horizontal. An example of private and horizontal is the case of three operators in Italy proposing to 'club' together to construct a fibre network in major cities.

Government participation in NGA

Central or local government participation with the private sector in NGA investment is now quite common *e.g.* New Zealand, Australia, Sweden, Netherlands. In this framework, separation can be enforced contractually (Singapore). Public bodies can inject limited funds and require 'open access' networks, but not necessarily separated (*e.g*. Portugal). Public/private partnerships or Joint Ventures in networks entail separation because of different ownership structures in network and retail layers (New Zealand).

In countries where governments are not inclined to follow the Australian or Singaporean example, governments are also nevertheless re-formulating their role in the industry. They are trying to reach similar goals but are approaching their goals via indirect means. They are setting far-reaching next generation broadband deployment targets, but basically rely on the investment decisions of the private business entities,[107] provide some public funds or low interest debt money, try to reduce the deployment cost by various measures and try to provide incentives for investment in NGA by relaxing the regulatory regime.

Some argue that in many countries, it is likely to be economically infeasible to build out FTTH throughout the country even with reasonable government support. Given this, policy makers need to give careful consideration to alternative technologies with a lower incremental cost of deployment. In countries with widespread coverage of cable networks one option could be upgrading this infrastructure with DOCSIS 3.0. In other countries, various wireless technologies may be considered. If public funds are used to upgrade these networks various way of opening the networks to competing service providers should be evaluated.

Fund and deploy a prospectively structurally separated NGA wholesale operator

Under this model government involvement accepts complete public ownership (temporarily in the case of Australia) of a separated network access. Singapore, Australia and New Zealand adopt a structurally separated model but with emphasis on local access wholesale. The contrasting approach taken in Singapore and Hong Kong, China is notable. Both are geographically small, with high population density and apartment living, but while Hong Kong china, has opted to deregulate and withdraw access regulation, the role of government is prominent in Singapore's approach to developing a national next generation optic fibre broadband network with mandated vertically separated infrastructure and services.

Notably, an important difference between the traditional state-owned monopoly model and the Australian NBN model is that the new state-owned network monopoly will only be allowed to offer wholesale services. That is, it is not vertically integrated into the retail business (which has been the case in the former state-owned telecommunications structure). Therefore it will in effect be structurally separate from retail service provisioning, the intention being the avoidance of access problems and a reduced need for access regulation. This means that the monopoly status is only over the basic infrastructure level while reliance is on private sector initiatives and competition on the upper levels of the network (the service and the content layers). In the Australian approach, while the government will deploy the NBN, sometime after the network is built and operated, the government conditionally plans to sell down its interest.

Table 5.1. Approaches to NGA market structure, access and development in selected countries

Category	Countries	Comments
Primary reliance on market forces for NGAs	Finland, Hong Kong, China, Korea, Switzerland, United States	The presence of extensive coverage of cable service is an important factor
Determine where bottlenecks are and take action through access regulation	Austria, France, Portugal and most other OECD countries	Most countries are making some effort in regard to access regulation
Develop end-to-end infrastructure competition through LLU but without imposition of functional or structural separation	France, the Netherlands, Germany, Portugal, Spain and Ireland	The relative success of ex ante access regulation, including LLU is considered an important contributing success factor; Portugal was a pioneer in adopting the Reference Conduit Access Offer (RCAO)
Access regulation plus functional separation	United Kingdom, Italy and New Zealand	Functional separation has been installed as a complement to access regulation.
Facilitate deployment of a wholesale backbone network	Chile, Italy, Argentina	Government initiatives to catalyze or fund a high speed backbone network
Government participation in NGA fibre deployment	Australia, France, Japan, New Zealand, Portugal, Singapore and Sweden	e.g., government-private sector co-operative arrangements have been used in these countries.
Deploy a prospectively structurally separated NGA wholesale operator	Australia, New Zealand and Singapore	At the extreme, 100% government funded (although with intention of privatising in 8 years)

5.4 Geographically segmented and differentiated regulation

Some countries have withdrawn or are forbearing from access regulation *e.g.*, on the basis of prevailing and prospective infrastructure competition. But, as has been the case with current generation broadband deployment, there may be geographic areas where the market fails to provide NGA in a timely fashion, possibly not even at all. In this context, some form of government involvement may be necessary to address any market failure and the varying market structures regarding supply of wholesale access products that prevail in different regions of a country.[108] Countries have taken different approaches to this issue. Some consider that geographically segmented or differentiated regulation is necessary.[109] The European Commission's guidelines for public funding, discussed earlier, are an example of geographic differentiation in the provision of government subsidies.

Geographically segmented regulation enables the benefits of deregulation to be realised in certain locations where effective competition has developed, even if the competitive situation would not warrant such deregulation throughout a country.[110] Regulators could also use geographic segmentation to impose additional regulation in a targeted manner in the specific locations where regulation proves necessary *e.g.*, because the market structure is one of only a single supplier or a duopoly. As with regulation at the national level, the criteria applied by regulatory authorities to justify regulation or deregulation on a geographically segmented / differentiated basis should be robust, evidence-based, consistent, and they should lead to non-ambiguous decisions. There is need for as clear and unambiguous criteria as possible according to which the geographic units are grouped, competitive conditions assessed and remedies applied. The experiences of countries that have implemented geographic regulation confirm the need for such criteria.[111]

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ENDNOTES

1 In this document NGA refers to networks that require fibre close to the end-users or providing the direct connection. For example, cable networks using DOCSIS 3, copper networks using VDSL 2, various forms of Fiber-to-the-Home (FTTH). This does not include DSL networks and traditional cable networks using DOCSIS 1.1.

2 *The Local loop*, also referred to as the "Last Mile" or "distribution" network, is the network that connects end-users to central switching facilities, and through those, to the backbone or transport networks. This last mile network, traditionally copper, has in recent years also been provided by cable television networks and wireless. But next generation access networks are increasingly fibre-based.

3 *Market structure* refers to the interconnected characteristics of a market, such as the number and relative strength of buyers and sellers and degree of collusion among them, level and forms of competition, extent of product differentiation, and ease of entry into and exit from the market. Four basic types of market structure are *i*) Perfect competition: many buyers and sellers, none being able to influence prices; *ii*) Oligopoly: several large sellers who have some control over the prices; *iii*) Monopoly: single seller or dominant seller with significant market power (SMP) over supply and prices. (4) Monospony: single buyer with considerable control over demand and prices. Businessdictionary.com. Available at:www.businessdictionary.com/definition/market-structure.html#ixzz11uUy6fhH

4 See OECD, "Network Developments in Support of Innovation and Users Needs", DST/ICCP/CISP(2009)2/FINAL.

5 "Operational separation" is designed to address concerns that arise from an incumbent's ownership of the infrastructure which other telecommunications companies need to access and interconnect with in order to provide services to consumers. Operational separation promotes transparency and equivalence in the incumbent's supply of key services to other telecommunications companies. The supply of key services to other telecommunications companies must be equivalent to the supply of the services to its own retail business units.

Under operational separation applied in Australia in December 2006, Telstra must maintain separate retail, wholesale and key network services business units. Telstra's retail business units must have no control over, or responsibility for, the marketing, contracting or supply of services to wholesale customers.

6 In the United States, the phrase "structural separation" is used to refer to the requirement that services be provided through separate corporate subsidiaries, which may be commonly owned.

7 PON technology avoids the placement of electronics in the field by using passive optical filters (splitters) to distribute optical circuits to individual customers. It reduces the amount of fibre and local exchange and field equipment needed. In PON architecture the prime switching and routing is handled at the Carrier's local exchange. At the customer's premises optical signals are processed and routed to individual devices such as video, voice or data. The key advantage of this technology is that the optical splitter does not require power, lowering both the installation and operating cost. By removing a potential point for failure, namely the power supply, the risk of downtime is also reduced.

8 Fibre-optic networks carry signals using light and are unaffected by distance. Whereas broadband "local loops" provided by copper have a relatively limited range (*e.g*. 2 to 5 kilometres depending on the technology used), high speed broadband based on fibre access links is possible for distances of 20 km and more. Currently gigabit passive optical networks (GPON) have coverage distances of up to 20 km, and in the near future, probably to 60 km. For point-to-point it depends on the optical interface, the coverage can be more than with GPON (BEREC 2010).

9 Central switch that connects the DSL line to the backhaul network. It lifts the IP-packets from the DSL-signal and sends them on.

10 Main Distribution Frame. The central location of a telephony network that aggregates the telephone lines and connects them to the switch.

11 Optical Distribution Frame: similar to an MDF, but for fibre networks.

12 O'Shea, D (2010), "FTTH pushes past 20 million homes, 6.3 million connections." *Connected Planet Online*. 15 September.

13 O'Shea, D (2010), "Move over FTTH, copper's back in style." *Connected Planet Online*. 8 September.

14 Vectored DSL uses advanced signal processing techniques to mitigate or even completely eliminate crosstalk; Line bonding uses several copper lines at the same time; DSL Phantom Mode significantly increases the speeds of DSL services provided over multiple copper pairs. It does not only send independent signals over each pair of wires, but also between the pairs. In this way, two pairs of wires can deliver three to four times the data rate of a single pair, rather than the doubling that would occur with bonding of two pairs alone.

15 ERG (2004), *Wholesale Broadband Access via Cable.* ERG (04) 19 rev1. Available at: www.erg.eu.int/doc/publications/consult_add_cable_netw_chapter/erg0419rev1_wholesale_broadband_access_via_cable.pdf

16 AT&T argues that engineering standards followed by cable modem operators may be much more conservative as to how many subscribers may share a CMTS (as in the United States). Also, providing a DOCSIS 3.0 CMTS with 160down/120up capacity requires the use of only about 42 MHz of the cable system's total coaxial spectrum. Because modern CATV systems contain 860 MHz of spectrum, several DOCSIS 3.0 CMTS may be provisioned over a system.

17 Ofcom 2010c.

18 Ibid.

19 Reported in Plum Consulting (2008).

20 Goldstein, M. and Herbst-Bayliss, S (2010), "Phil Falcone's riskest trade ever?" *Reuters Special Report,* 26 August.

21 Tucker, R (2010), Back on the superhighway". *The Age Newspaper*. 9 September. Professor Tucker is Director of the Centre for a Broadband Enabled Society based at the University of Melbourne.

22 Location where networks terminate and interconnect.

23 As a further example of the intense debate over technology issues, it is noted here that AT&T argues that this observation ignores two things. "First, it is rare that each and every subscriber will wish to saturate their line at exactly the same time. Because of this, GPONs can currently be engineered to allow individual

customers speeds of 150 Mbit/s and more. And second, it is a surety that the amount of backhaul currently provisioned, either on a PON or on a Point-to-Point fiber system, will be far, far less than 39 Mbit/s per subscriber. Thus, the effective limit to maximum simultaneous use will be the backhaul, and this will not differ between PON or Point-to-Point systems. But even more overriding, PON technology will continue to evolve to meet customer demand. PONs operating at 10 Gbit/s have already been developed, and if need expands, even faster speed PONs will surely be developed. Indeed, PONs will only possibly fall short of Point-to-Point in their capability once every individual customer wishes simultaneously to saturate more than 1/64th of the total potential throughput of a fiber optic line – which will be multiple Tbit/s per subscriber. Because these capacities are simply beyond any foreseeable need, concern over lack of bandwidth in PONs certainly should not be a worry of policy makers for many years to come." (AT&T submission to OECD.)

24 Neumann, Karl-Heinz (2010), *Structural models for NBN deployment*. Paper presented at the Eleventh ACCC Regulatory Conference "Market Structure Revisited" Surfers Paradise, 29-30 July 2010. Available at: www.accc.gov.au/content/item.phtml?itemId=941686&nodeId=97c29e39b72ec05ebac427e3808be61f&fn=Dr.%20Karl-Heinz%20Neumann%E2%80%94paper.pdf.

25 See, for instance, OPTA (2008); Ofcom (2010c).

26 See, for instance, ERG (2009); ECTA (2009); BEREC (2010c).

27 INTUG submission to OECD.

28 It is possible to develop a factor to deal with this issue, however. Se *e.g*., David M. Mandy and William Sharkey, "Dynamic Pricing and Investment from Static Proxy Models", Federal Communications Commission, OSP Working Paper Series, No. 402033 — available at www.fcc.gov/osp/workingp.html.

29 ACCC (2010).

30 www.atkearney.com/index.php/Publications/a-viable-future-model-for-the-internet.html.

31 Genachowski, J (2010), *The Third Way: A Narrowly Tailored Broadband Framework*, Federal Communications Commission, 6 May. See also OECD (2007), Internet Traffic Prioritisation: An Overview, DSTI/ICCP/TISP(2006)4/FINAL. JTO325145. 6 April. www.oecd.org/dataoecd/43/63/38405781.pdf.

32 http://googlepolicyeurope.blogspot.com/2010/08/joint-policy-proposal-for-open-internet.html.

33 The following are key excerpts from the Report and Order adopted by the FCC:

Rule 1: Transparency: A person engaged in the provision of broadband Internet access service shall publicly disclose accurate information regarding the network management practices, performance, and commercial terms of its broadband Internet access services sufficient for consumers to make informed choices regarding use of such services and for content, application, service, and device providers to develop, market, and maintain Internet offerings.

Rule 2: No Blocking: A person engaged in the provision of fixed broadband Internet access service, insofar as such person is so engaged, shall not block lawful content, applications, services, or non-harmful devices, subject to reasonable network management.

A person engaged in the provision of mobile broadband Internet access service, insofar as such person is so engaged, shall not block consumers from accessing lawful websites, subject to reasonable network management; nor shall such person block applications that compete with the provider's voice or video telephony services, subject to reasonable network

Rule 3: No Unreasonable Discrimination

A person engaged in the provision of fixed broadband Internet access service, insofar as such person is so engaged, shall not unreasonably discriminate in transmitting lawful network traffic over a consumer's broadband Internet access service. Reasonable network management shall not constitute unreasonable discrimination.

34 Density is often used as a proxy for loop length, but a focus on density in itself can be misleading. For example, two countries with the same average population, may exhibit very different costs of broadband development.

35 Neumann (2010), op. cit.

36 Submission to OECD from France.

37 In some cases, however, incumbents might only be allowed to phase out MDFs over a long time period to allow new entrants to adjust.

38 Wiring costs can be compounded through difficulties with the physical condition of buildings (*e.g.* availability of internal trays) or with the house owners. According to the French regulator, Arcep (2006), indoor wiring costs range from €300 to €500 per customer.

39 OECD (2007); Neumann (2010), op. cit.

40 WIK (2008).

41 JP Morgan (2006).

42 Analysys (2007).

43 Ibid.

44 Non-duplicable assets relate to those assets that either cannot be commercially duplicated by competitors in similar circumstances or cannot be substituted by deployment of alternative technologies.

45 ERG (2008), OECD (2010).

46 Neumann (2010) op. cit.. Details of Neumann's methodology, including assumptions used can be found in this paper.

47 Neumann (2010) op. cit.

48 This conclusion should be qualified. While infrastructure sharing can lower costs, it can also reduce revenues. This means that the net effect on profits seems unclear, unless one assumes that the competitors would be present even without infrastructure sharing.

49 European Commission (2010).

50 Neumann (2010).

51 WIK (2009).

52 Ibid.

53 Written response from ECTA to a question put to it by the OECD on 16 September 2010.

[54] Cave (2006).

[55] Duplicable infrastructure is used here to refer to other infrastructure capable of delivering the same services. Thus, the duplication does not need to be on the basis of the same technology and, even if it is, there is no assumption that it will be configured in the same manner.

[56] ERG (2009), ECTA (2009).

[57] Ofcom (2010c). Ofcom has now published the WLA market review (7 October 2010) and VULA is included. Available at: http://stakeholders.ofcom.org.uk/consultations/wba/wba-statement/

[58] For a detailed argument in support of mandating bitstream in an NGA environment see *e.g*., Lewin, Williamson & Cave (2010).

[59] Neumann (2010), op. cit.

[60] Examples include in the UK, the gas and electricity sectors and the fundamental restructuring of the rail industry. The US example involving the divestiture of AT&T's local telephony operations (Baby Bells) in the 1980s was mainly a form of horizontal separation, but with the introduction of competition for long distance calls.

[61] OECD (2001), Recommendation of the OECD Council concerning *Structural Separation in Regulated Industries* [26 April 2001 – C(2001)78] ; OECD (2003), *The costs and benefits of structural separation of the local loop*.; OECD (2006), *Report on Experiences with Structural Separation*, Competition Committee, June.

[62] OECD (2003).

[63] OECD (2006), *Report on Experiences with Structural Separation*, Competition Policy Committee, June.

[64] Ofcom (2010c).

[65] Onwurah (2009).

[66] IDA (2008), "*Industry structure for next generation access networks*", Consultation paper, Info-communications Development Authority of Singapore, 17 April.

[67] EU Parliament (2009).

[68] See Ibid, Article 13, No. 1.

[69] The wholesale network operator does not necessarily have to own and control all parts of the network. Historically, the issue of which parts of the network are bottlenecks has been widely debated.

[70] Minister for Communications, Information Technology and the Arts (2005), 'Telecommunications (Operational separation – designated services) Determination (No.1) 2005', *Explanatory Statement*, 2005.

[71] ACCC (2008).

[72] Battersby, L. (2010), "Telstra calls for a quick break-up", *The Age*. 21 October, p.2.

[73] AGCOM submission to OECD, September 2010.

74 Ministry of Economic Development, New Zealand (2007), *Development of requirements for the operational separation of Telecom*, Consultation Document. April.

75 Ofcom (2005a).

76 Ibid.

77 See Ofcom (2005b).

78 See British Telecom (2006).

79 EAB (2010), p.36.

80 Ofcom (2010c).

81 European Commission (2009).

82 Nucciarelli, A and Sadowski, B (2010), "The Italian way to functional separation: an assessment of background and criticalities", *Telecommunications Policy*. Volume 34, Number 7, August.

83 A number of commentators have pointed to this. For example Whalley and Henten (2010): "That incumbent operators have voluntarily opted for functional separation is partly explained by their desire to avoid the more intrusive and irrevocable imposition of structural separation on them, and arguably by the fact that even with functional separation there are significant advantages associated with owning the network." (p. 351)

84 Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services. L 337/37 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:337:0037:0069:EN:PDF

85 Kirsch, F and Von Hirschhausen, C (2008), "Regulation of NGN: Structural Separation, Access Regulation, or No Regulation at All?" *Communications & Strategies*. No. 69, 1st Q. 2008 March.

86 *La letter de l'Autorite de regulation des communications electroniques et des postes* (2007), No. 55, March/April.

87 Germany's submission to this OECD study. September 2010.

88 Howell, B., Meade, R and O'Connor, S (2010), "Structural separation versus vertical integration: Lessons for telecommunications from electricity reforms." *Telecommunications Policy*. Volume 34, Number 7, August.

89 Poulus, T (2010), "Singapore on top with NBN, Australia's plans near standstill", 2 September..

90 "Argentina plans state wholesale operator – report" *Telecom Paper*, 19 October 2010.

91 Molinari, C (2010), "Govt set to call for bids for new fiber optic network – Colombia", *Business News Americas*, 29 October.

92 Cave and Doyle (2007a).

93 For further details, see Berkman Report (2010), pp. 231-232.

94 Ministry of Enterprise, Energy, and Communications Sweden (2009), Presentation; ITIF Broadband Report, 4 June, p. 25; European Commission (2009), *Guidelines for State Aid*, September.

95 The following discussion draws on the Berkman Report (2010) together with subsequent events.

96 Erbium Doped Fiber Amplifier that allows the amplification of the signal. In this case to broadcast a traditional radio frequency cable signal over the fibre on a separate colour. Customers can get access to analogue and digital TV using existing broadcasting and cable standards without needing IPTV.

97 European Commission (2007), Final Decision on the State Aid Case C 53/2006, Investment by the City of Amsterdam in a fiber-to-the-home (FTTH) network; Herman Wagter, BH_CityNet presentation, 2009.

98 European Commission (2009), *Community Guidelines for the application of State aid rules in relation to rapid deployment of broadband networks*, September. Available at:http://ec.europa.eu/competition/state_aid/legislation/guidelines_broadband_en.pdf

99 Ibid.

100 Germany's submission to OECD, September 2010.

101 Cadman, R (2010), "Means not ends: Deterring discrimination through equivalence and functional separation". *Telecommunications Policy*. Volume 34, Number 7, August.

102 Jamison, Mark A. and Sichter, James (2010) "Business Separation in Telecommunications: Lessons from the U.S. Experience," *Review of Network Economics:* Vol. 9: Iss. 1, Article 3. Available at: www.bepress.com/rne/vol9/iss1/3

103 OECD (2007a); European Commission (2010).

104 ARCEP (2010); European Commission (2010).

105 Ofcom (2010c).

106 "Argentina plans state wholesale operator – report" *Telecom Paper*, 19 October 2010.

107 In Italy, for instance, the chairman of the regulatory agency, AGCOM, has urged operators to work together to develop a fast-fibre based network, warning that failure to do so could be costly for the country's economic growth and competitiveness. See Zampani, G (2010), "Italian regulator urges common broadband plan." *TotalTelecom.* 6 July. Available at www.totaltele.com/view.aspx?ID=456868

108 This issue was the focus of OECD (2010).

109 See e.g. ERG (2008); Ofcom (2010c); OECD (2010).

110 See ERG (2008). ERG *Common Position on Geographic Aspects of Market Analysis (definition and remedies*). October.

111 OECD (2010).