Incentives for investments in next generation telecommunications access networks and customer choice – A dichotomy?

Paper prepared for the conference "Telecommunications Infrastructure and Economic Performance", Paris 16 / 17 October 2008

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1 July 2008

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Abstract

"The central question for telecom – and for many other media – is how to generate the funds and invest in upgraded infrastructure, while being subject to competition"[2]. This is the paramount question for fixed telecommunications access networks, which in many regions constitute an economic bottleneck and are likely to become a technical bottleneck in the near future, since the increasing bandwidth demand of advanced broadband cannot be delivered via the existing copper plant. Since employment and economic growth are closely correlated to broadband penetration, the topic of upgrading the access network is now becoming more and more important on the agenda of the private and the public sector.

Private sector investment is preferable from an economical point of view but whether it will materialize depends on the existence of a positive and sustainable business case. Since investment in next generation access network is significant and mostly sunk, the optimisation of the revenue side is critical. The best way for the private sector would be to get some kind of a constant income stream, e.g. by exclusivity arrangements and not to share in a competitive environment. The public however is best served by competition at the deepest level of the value chain possible. Therefore a balance needs to be struck between incentives for investment and securing of competition in telecommunications. In our opinion this requires co-operation between the private and the public sector.

The paper is in our view best suited for topic 3 of the conference ("Telecommunications infrastructure and economic performance – The role of markets and institutions")

[2] See Noam (2007)

1 Introduction

Telecommunications continues to be key to economic growth and employment. The telecommunications market grows although the market segments develop in different directions. Mobile communication shows signs of saturation, fixed telephony revenue decreases on an average 5% per year and broadband is the sector with the strongest growth.[3] Broadband has the potential to become a general purpose technology with the ability to deliver many different electronic communications services. Service specific networks will disappear and be replaced by a common packet based infrastructure, upon which flexibly and quickly services can be built.

Information society depends on the possibility of all citizens to access digital information in an adequate manner. When other industries switch their supply chains and sales channels to the ubiquitous digital network, the basic information infrastructure becomes as critical as utilities like electricity and roads. Access to this infrastructure can be regarded as the critical bottleneck for the information society. As we will show the copper based access network as it exists today is not up to the challenge to fulfil the demand required by the information society.

2 Demand for bandwidth is increasing

2.1 Broadband statistics

Broadband is a term applied to transmission media with bandwidths that can carry multiple signals by dividing the total capacity of the medium into multiple, independent channels. Although broadband is sometimes regarded solely as access to the internet, other services envisaged comprise i.a. TV, HDTV, video on demand, gaming, messag-

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3 See European Commission (2008a). See also Thompson, Herbert Jr. (2008): Broadband Impacts on State GDP: Direct and Indirect Impacts, ITS conference Montreal July 2008; www.itsworld.org.

ing and telephony. Figure 1 shows the broadband penetration in OECD countries and the split into technologies used.[4]

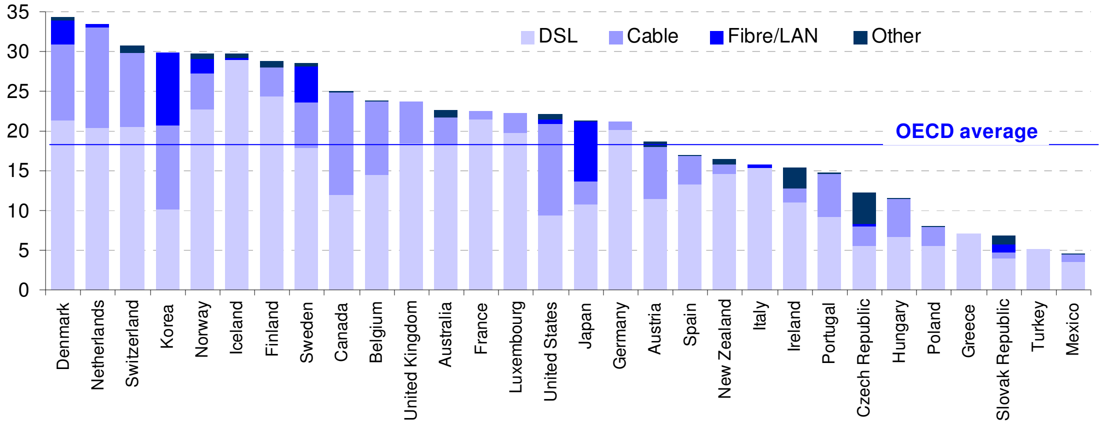

Figure 1: OECD broadband penetration, June 2007

All statistics depend on a definition of "broadband". There is, however, no universally agreed definition and the required size of the bit-pipe depends on applications. If more bandwidth is available, applications start to use it and the user's perception of broadband changes. Scorecards and statistics thus become vulnerable and might lose their significance. Furthermore, the definition of broadband is also time-sensitive. What was regarded as broadband yesterday may be far away from broadband today and narrowband tomorrow.

The OECD, which provides the most widely cited international rankings of broadband adoption, has defined broadband as a service that enables users to upload or download data or both at a speed of 256 Kbps – and this rate is the most common baseline that is marketed as "broadband" around the world[5]. Recently, the FCC specified the following seven tiers in its broadband definition[6]:

- First-generation broadband – 200 Kbps to 768 Kbps;

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4 See OECD broadband portal - http://www.oecd.org/sti/ict/broadband. The total number of broadband subscribers in OECD countries in June 2007 was 221 million. The European Commission reports nearly 100 million broadband lines with 1. January 2008.

5 3G mobile and WiFi are not included in the OECD broadband statistics.

6 See ITIF (2008)

- Basic broadband tier 1 – 768 Kbps to 1.5 Mbps;
- Basic broadband tier 2 – 1.5 Mbps to 3 Mbps;
- Broadband tier 3 – 3 Mbps to 6 Mbps;
- Broadband tier 4 – 6 Mbps to 10 Mbps;
- Broadband tier 5 – 10 Mbps to 25 Mbps;
- Broadband tier 6 – 25 Mbps to100 Mbps and
- Broadband tier 7 – more than 100 Mbps.

We will see more differentiated statistics in the future. This gives way to enhanced growth opportunities since especially the higher broadband tiers are in their infancy in many countries. The perception of what broadband is, becomes more differentiated. As more bandwidth becomes available, the more bandwidth hungry the applications become, which triggers new demand. This virtuous circle is widely regarded as an important engine for economic growth, employment and innovation in the emerging information society. Statistics and league tables carry quite a significance and put broadband on the political agenda of the nations lagging behind. A picture of consecutive broadband generations has been drawn by Technology Futures Inc.[7] (Figure 2).

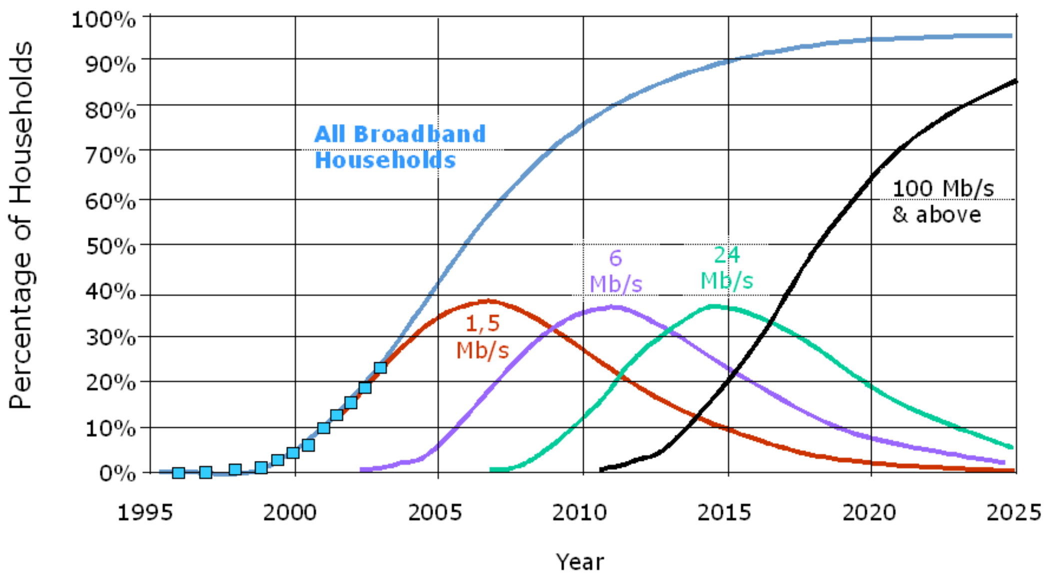

Figure 2: A more differentiated view on broadband penetration

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7 See TFI (2005)

A frequently posed question is, which specific applications will need this ever increasing bandwidth, what will the market pay for them and – more importantly – who will provide for the necessary infrastructure?

2.2 Exponential access bandwidth growth – A self-fulfilling prophecy ?

In order to understand the evolution of bandwidth demand it is worthwhile to look at the bandwidth increase since the early 1980s. Jakob Nielsen predicted in 1998 that a high-end user's connection speed grows by 50% per year.[8] This has become known as Nielsen's law of bandwidth. In 2008 Jakob Nielsen acquired a 16 Mbit/s cable modem and showed that empirical data fits the predicted growth curve quite well (see Figure 3).

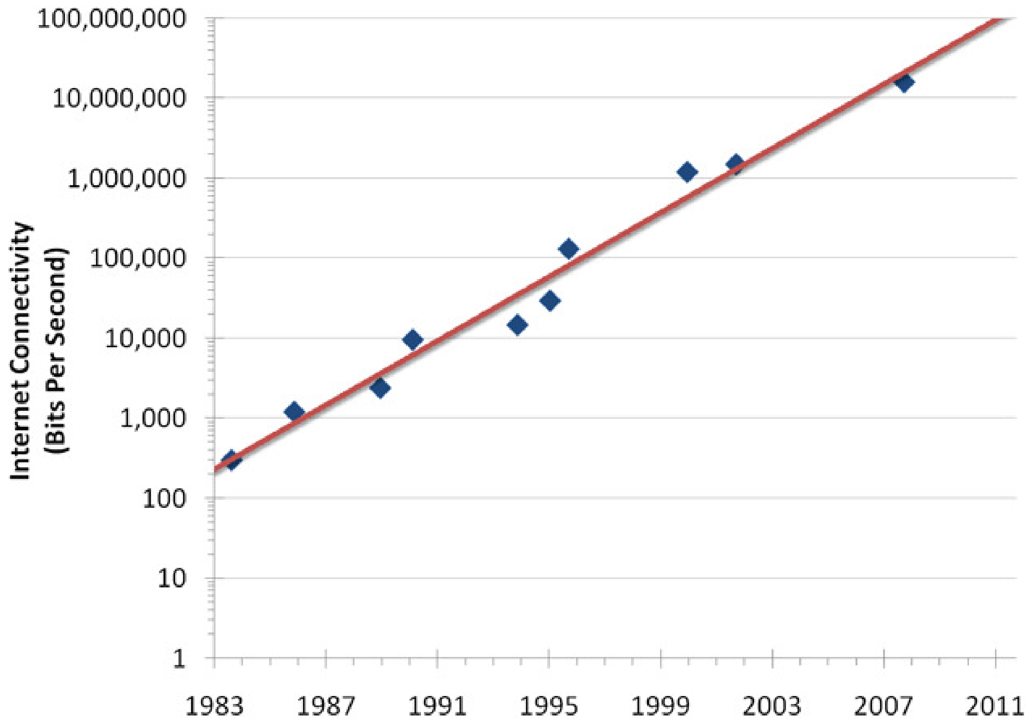

Figure 3: Nielsen's law of bandwidth

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8 http://www.useit.com/alertbox/980405.html

Similar to Moore's law one can ask, if this is a purely technology driven development or if economic growth depends on the continuation of this trend. Indeed Nemertes Research interpreted Nielsen's law as a demand curve and asked if supply will be able to fulfill further exponential growth. The study concludes

> "*that although core fiber and switching/routing resources will scale nicely to support virtually any conceivable user demand, Internet access infrastructure, specifically in North America, will likely cease to be adequate for supporting demand within the next three to five years.*"[9]

The investment needed to "bridge this gap" is estimated to be between $42 billion and $55 billion.[10] When due to the lack of investment in access infrastructure the curve flattens out,

> "*this will throttle innovation – both the technical innovation that leads to increasingly newer and better applications, and the business innovation that relies on those technical innovations and applications to generate value. The next Google, YouTube, or Amazon might not arise, not because of a lack of demand, but due to an inability to fulfill that demand.*"[11]

It could be that, even if applications are not known or indeed cannot be known, the necessity to expand broadband penetration and speeds can arise.

2.3 The demand for NGA is driven by the whole economy

Demand for broadband does not only come from the user side but is also derived from other segments of the industry (because Internet is regarded as a multi-sided market) and also from the general public. State-of-the-art telecommunications infrastructure in general and broadband in particular are widely regarded as necessary prerequisites for

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9 See Nemertes (2007)

10 Some authors suggest that currently Europe is lagging behind in investment whereas investment in next generation networks in North America is being undertaken, see Crandall, R.: Through a looking glass dimly: Future Issues in Telecom Regulation, Presentation at the ITS 2008 conference, Montral, http://www.canavents.com/its2008/plenary3/10.pdf, pp. 6. On the topic of achieving investment and competition also see Elixmann, Dieter, Marcus, Scott: International Regulatory Comparisons, The Evolution to IP-Based Fibre, ITS conference Montreal July 2008, pp. 18. On the interrelationship between investment and regulation see Brandl, Margit, Wieck, Reinhard (2008): Can Regulation Forster Investment or not? An operator's and manufacturer's point of view, ITS conference Montreal July 2008, http://www.itsworld.org

11 See Nemertes (2007)

economic growth. Forfás in Ireland has put the advantages of advanced telecommunications services into three categories:[12]

- Broadband and enterprise development: Advanced telecommunications services are critical for the attraction of foreign direct investment, for the development of indigenous industry and the promotion of the knowledge economy.

- Broadband and Productivity: Broadband increases productivity by allowing firms to cast their net wider when looking for suppliers or seeking new market opportunities to increase their customer-base and by more effectively linking business functions.

- Societal benefits of broadband: For Government, broadband can improve the efficiency, availability and reach of public sector services in areas such as health, education and other government services; for consumers, broadband can enhance the quality of life through economic, social and cultural development; and for small, rural, and remote communities it can be an enabler for economic and social inclusion.

In a recent U.S. study a regression analysis of the effects of broadband on employment and economic output has been conducted.

> *"Empirical investigations of state data on broadband penetration, employment and output thus suggests that employment is rather strongly related to broadband deployment, particularly in certain service sectors, such as finance, education, and healthcare."*[13]

One percentage point increase is associated with nearly 300,000 more jobs.

> *"The effect on output growth is less precise, but once again the statistically significant effects of broadband penetration on output growth appear to be concentrated in the service industries."*[14]

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[12] See Forfas (2006)
[13] Crandall (2007)
[14] ibid.

In a similar study US data from the FCC on broadband availability have been matched with demographic and other economic data from the US Population Censuses and Establishment Surveys. This study supports the conclusion that broadband positively affects economic activity:

> "*Even after controlling for community-level factors known to influence broadband availability and economic activity, we find that between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in (1) employment, (2) the number of businesses overall, and (3) businesses in IT-intensive sectors.*"[15]

These studies underline that advanced telecommunications services in general and broadband in particular are drivers for employment, productivity and enhance general welfare. In this respect we can regard broadband infrastructure as a utility like streets, water and electricity and the question arises if financing should be done in a similar way – although the degree of competition and market opening may be significantly different.

2.4 Conclusion on the demand side

Although a trend of exponential growth in demand can be recognized, it is rather difficult to predict which specific applications will provide the required revenue streams for telecommunications service providers. Therefore it is also difficult to establish positive business cases for investment in next generation access network. This becomes even more difficult if the access provider cannot tap into the services market, as is the case with transparent internet access.

Additionally, the telecom market has moved from monopoly to competition (on all levels of the infrastructure and value chain). This implies that there are no such things as stable and secure revenue streams. Network rollout and the massive investments have to be borne by revenue from competitive business fields and not on inherited rents from the past. This may lead to a reluctance to invest under uncertain conditions of payback

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15 See Lehr, Osorio, Gillett, Sirbu (2006)

– especially for companies which are actually or potentially regulated and would like to share the benefits of new technology with new entrants at regulated prices.

A robust economic model requires the cost being distributed to those who benefit from it. Clearly, the beneficiaries of such investments are various kinds of users but also the economy as a whole due to the increased attractiveness and competitiveness of the location. Therefore, such networks may have facets of public good character. As we have shown demand on access infrastructure is not only expected from consumer side but also – even more – from enterprises. As many sectors of the economy and indeed the society as a whole benefit from next generation access infrastructure the question arises if the public should at least pay part of the infrastructure. The incentives for investment by the "usual suspects" (i.e. the telecommunications industry) are rather weak.

3 Will supply fulfil the demand?

3.1 Copper based access networks

Having established a case for demand, we need to analyse the supply side. For this end we will look at the economic and technological particularities of the existing network infrastructures (copper, cable and wireless).

3.1.1 The copper based access network constitutes an economic bottleneck

(Copper based) access networks have widely been regarded as economic bottlenecks in the past, especially after the market opening in many countries which demonstrated that competition could be established on the conveyance level fairly easily but that it was difficult (economically) to replicate the copper based access network. The bottleneck character of the access networks depends partially on the existence of cable networks as alternatives. Regulators have therefore imposed obligations on incumbent operators to make this essential facility available. Business models of alternative operators depend to a large extent on physical (unbundled local loop) or virtual (bitstream) access to the local loop.

The political goal however is infrastructure based competition. Alternative technologies in the access are cable networks and wireless solutions. Both technologies display technical constraints. Cable is only available in specific regions while wireless is not deemed capable of becoming equivalent to wired technologies in terms of economical provision of the same bandwidth.

3.1.2 The access network will become a technical bottleneck

The copper access networks have been built by the incumbent network operators and were financed in a monopoly environment. The layout was targeted for a ubiquitous availability of the copper loop. Since liberalisation was introduced, investment in the access network have been scaled back and strategy focussed on the exploitation of existing assets. Digital subscriber line is the successor technology to the analogue transmission over the local loop. The first digital technology was ISDN with a transmission rate of 144 kbit/sec. This was followed by asymmetric DSL technologies designed to allow data transmission in addition to the basic PSTN/ISDN connectivity. Figure 4 shows the evolution of DSL technologies.

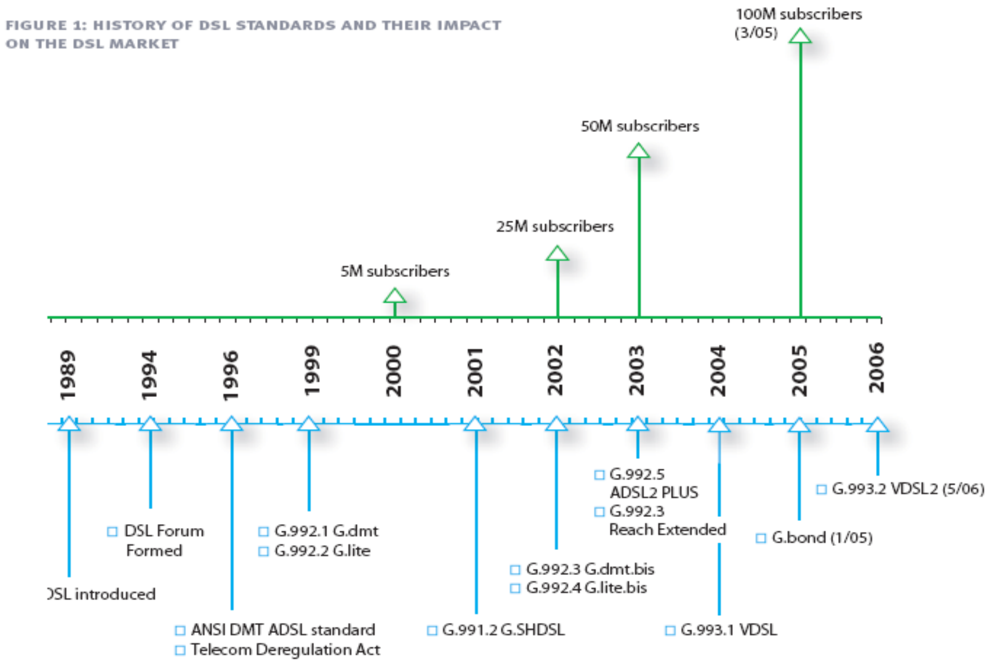

Figure 4: History of DSL standards

While ADSL can be deployed from the central office, VDSL2 – allowing higher speeds – requires a hybrid network, consisting of fibre and copper. As Figure 5 shows bandwidths over 50 Mbit/s are only possible up to 1 km distance on copper wires. For longer copper loops there is no benefit in deploying VDSL vs. ADSL, because it does not offer superior bandwidth.

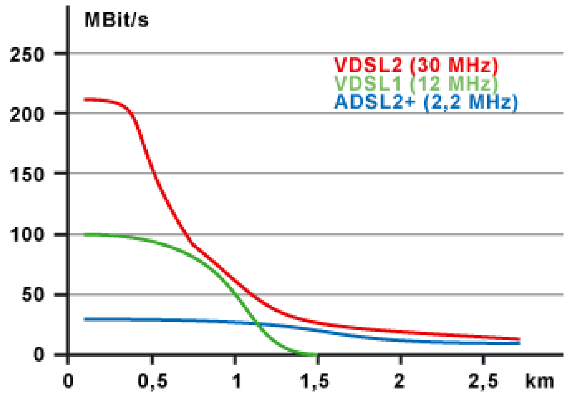

Figure 5: Bandwidth vs. distance for various DSL technologies

3.1.3 Conclusion

We conclude that copper-based access – being an economical bottleneck – is becoming a technical bottleneck as well. Since broadband is regarded as a main driver for economic growth and employment, the question of upgrading (or replacing) the copper access networks gains importance.

This faces a massive constraint, though. Copper access networks have been established in times of monopoly. Justifying this investment against a monopoly situation and growing demand was easy. After competition was introduced investments are more critical. Incumbents become more prudent as they would like to avoid to make investments which pave the inroad to new competitors via regulation and new entrants will focus their investments on attractive market segments. However, broadband is an essential utility for the information society and requires access networks capable of handling the growing bandwidth. As a delicate balance has to be struck between investment incentives and competition, the technical characteristics of fibre may have a tendency for restating the access monopoly – dependent on the market conditions in specific locations. So, access based on fibre could also become an economic bottleneck again.

3.2 Next Generation access networks

There is wide agreement that the copper access network will have to be replaced by other technologies in the future in order to fulfil the demand. Candidate technologies are wireless, cable and fibre.

3.2.1 Cable

The cable network uses a mixture of optical fibre and coaxial cables. The coverage of cable networks is usually much lower than with copper access. Bandwidth offered is in the range of 2 Mbps, 4 Mbps and 20 Mbps. The bandwidth of cable broadband does not decrease significantly with distance, but bandwidth is shared by several users.

3.2.2 Wireless

Industry analysts predict that mobile access to the internet will become increasingly popular. Existing 3G mobile technology supports downloads of up to 2 Mbps, and technologies in development such as 3.5G and 4G will increase this significantly. These technologies will require additional radio spectrum. As bandwidth increases cells are getting smaller (e.g. femto cells) and fixed infrastructure is needed to feed the base stations. If these cells get sufficiently small there is no difference in demand of fixed fibre infrastructure between a wired and a wireless network.

3.2.3 Fibre

It is generally agreed that the most future-proof option for broadband access is laying new optical fibre cables. These are glass fibres that use light to transmit a signal with a symmetric speed of 100 Mbps or more. Optical fibres are already used for the backbone networks of telecoms companies, but extending them into the access network is costly. There are some options for fibre deployment:

- Fibre to the home (FTTH), where each customer has a fibre coming into the home, providing very high bandwidth and reliability,
- Passive optical network (PON), where only passive components (optical splitters) are used within the access network, lowering the maintenance cost compared to deployment of active components,
- Active star, where active components (routers) are placed into the network, allowing concentration of fibre cables; and
- Fibre to the cabinet (FTTC), where fibre runs from the exchange to street cabinets but existing copper (probably using VDSL) is used for the final link into the premises. This is cheaper to deploy than FTTH, but new equipment must be installed in street cabinets, increasing maintenance and power costs and potentially reducing reliability.

3.2.4 Investment into next generation access

The introduction of optical fibres into the access network is expensive and only being undertaken by few operators on a large scale (e.g. Verizon, NTT DoCoMo and Korean Telecom and also Sweden and the Netherlands). The cost of fibre deployment can be segmented into four parts:

- Fibre and the infrastructure to lay it in or to string it on. The investments in aerial plants (fibre strung over poles), trenches, locations for Points of Presence and other physical infrastructure often account for 30-80% of total investment costs and will last for at least 30 years, although they are often economically written off in 15 years.
- Active components in the network, i.e. all the optical and electrical systems that make the network send and receive signals, such as switches, repeaters, etc. These need replacing every 5-7 years.

- Customer premises equipment: equipment like modems and, if offered, decoders for IPTV/digital TV.

- Personnel charges: management, network administration, billing, repair crews, customer support etc.[16]

We have examined a number of studies related to the cost of fibre deployment in the access network. Although the methods of research vary and so the results might not be exactly comparable, a number of conclusions about the roll-out of fibre can be drawn:

- Infrastructure costs are between 60 and 80% of fibre deployment. In this respect infrastructure includes ducts and cables. The cable itself is only about 6%.

- There is no significant cost difference between deploying fibre cables or copper cables.

- Best practices for the cost of fibre deployment are around 1,000 € per home connected. Prices are coming down.

- PON is in general cheaper than active star or home-run fibre.

3.2.5 Conclusion

The most future proof technology in access networks is fibre optic cables. Wireless technologies will play a role for users or applications who require less bandwidth or in less populated areas. Cable networks will need to reduce the shared part of the network, which leads to increasing deployment of fibre in the local loop.

The cost of fibre optic access networks is around 1000 € per home passed.

There are different intermediate steps and different ways but from today's view the most future proof technology is home run fibre optic cables. The technical arguments about comparison of technologies lead to doubts if infrastructure based competition is feasible. Recalling the differentiation into broadband tiers, the ability to deliver comparable services through wireless, cable and fibre might exist in lower tiers but the higher the bandwidth, the greater the advantages of optical fibre in the access network.

Given the importance of broadband, two questions arise:

- Will the market forces suffice to provide fibre based access network? Furthermore will they cover all areas or just selected spots, where demand is regarded as sufficiently high.
- If fibre based access networks will be rolled out, will sustainable competition be possible? A simple calculation shows that given cost of 1000 € per home passed and an ARPU of 30 €, return on invest will be about 9 years provided 50% uptake rate. If two or more providers are going to roll out fibre, the market is shared between these companies and either some revenue generating services need to be introduced or the time frame needed for return on invest increases significantly.

This might lead to the conclusion that prices need to come down in order to allow competition in access networks. On the other hand – given the importance of broadband for economy and society – other countries or regions might find other forms of investment to roll-out fibre based access networks and so gain competitive advantage.

4 Obstacles to investment

Traditionally telecom operators are the entities responsible for access networks. However they have been rolled out under monopoly conditions. One might also say that the public is the entity responsible for access networks. It all depends on the fact, if access networks form an enduring bottleneck. Today telecoms operators are reluctant to invest in next generation access networks. These obstacles can be grouped into two main categories:

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[16] [OECD 2008], p. 20.

4.1 Market uncertainty

The market uncertainty comprises two aspects: This is the uncertainty on the demand side ("demand uncertainty") as well as the uncertainty on the supply side ("investment uncertainty"). The first aspect refers to the difficulty for telecommunications operators of assessing the demand side of the market. We have alluded to this aspect in chapter 2. This demand uncertainty is accompanied by an investment uncertainty on the supply side, because the companies that may be investing are currently unsure regarding the regulatory framework that may apply to NGA but also regarding the overall project costs and technological developments.

Obstacles can also be interrelated, e.g. the lack of regulatory clarity may (in addition to demand uncertainty) lead to hesitancy in investing in long-lived assets like fibre-optic cables. Therefore, investment uncertainty could arise as an obstacle resulting from demand and regulatory uncertainty. The investment uncertainty focuses on the amount of investment and the share of investment for each major building block of the activities (see 3.2.3).

If state-of-the-art fibre infrastructure is deployed in the access network, the crucial question remains as to whether the take-up rate networks, services and usage will allow the economic viability of the investment to materialise, and this is one of the main hurdles for infrastructure investment.

Whether investment in physical infrastructure will form a sustainable business case for the future (and if so, based on which technology), or whether service-based competition will prevail in the future, is difficult to answer. The assessments of the supply and demand side are also interrelated and influence each other in a cyclical way. This means that, while the public value of next generation broadband for society and the economy as a whole is potentially high, the large scale of investment combined with a significant number of uncertainties surrounding the prospects for recouping that investment mean that the potential private value available to investors is comparatively weak. Considering this gap, the current infrastructure, and planned investment in that infrastructure, may not be able to support the demand for bandwidth in the medium- to long-term. This implies the requirement to consider the responsibilities of the parties involved for investments in next generation access networks to overcome this gap.

4.2 Regulatory uncertainty

The *regulatory uncertainty* concerns the elements of the current regulatory framework (such as existing obligations and remedies, e.g. to offer certain infrastructure wholesale products) as well as the future design of the regulatory framework, especially with respect to the position of the regulatory authority regarding the balance between infrastructure-based and service-based competition. It is as yet unclear what (if any) obligations may be levied upon networks which are being rolled out at this point in time. Under such regulatory uncertainty, investments tend to be regarded as risky, and may not be made in such high volumes as when the investment conditions in the regulatory framework were clear. The desired regulatory certainty is intended to give clear directions with respect to the balance between infrastructure-based and service-based competition. Where economically feasible, infrastructure-based competition is favoured above service-based competition due to the advantages that can be achieved (e.g. a structural safeguard with respect to independence of new entrants and incumbents due to a larger portion of self-provision of elements of the value chain), but to make this type of competition happen, usually a longer period of time is necessary. Therefore, service-based competition may have advantages in the short term. Looking at other regions, one can conclude that e.g. the EU has taken a positive approach to the "parallel roll-out" of ICT infrastructure. Infrastructure competition, in which different network owners compete with one another in offering services to end users, has the advantage that it creates competitive pressure throughout the value chain. Infrastructure competition also requires less regulation, since the same needs do not arise as with competition in services with regard to ensuring that competitors can obtain access to the infrastructure on non-discriminatory terms higher up in the value chain. At the same time the duplication of infrastructures is an economic concern in case such duplication would lead to inefficient investment and inefficient market entry as this could harm all market players.

Concluding from these uncertainties it is necessary to consider if other stakeholders should intervene to overcome these obstacles.

4.3 Conclusion

The rollout of fibre optic networks takes place in a world with a large degree of uncertainty. This uncertainty may imply certain obstacles for the optimal amount of investment. Also other analysis show a similar summary of the reasons for uncertainty on the part of the operators (Figure 6). [17]

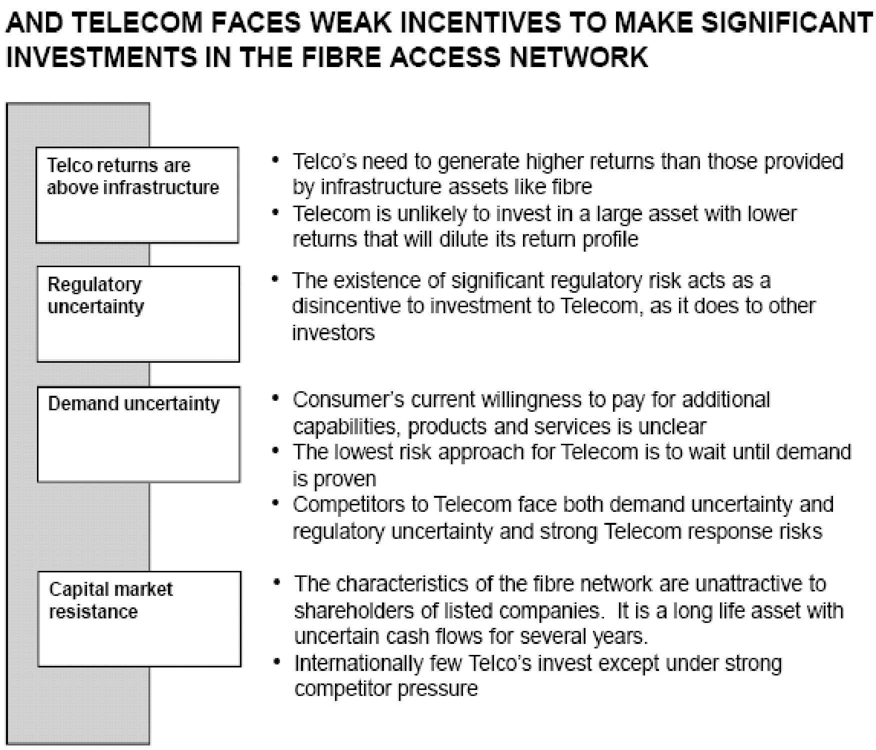

Figure 6: Obstacles to invest

Fibre optic cables are long-lived assets and will not yield return-on-invest soon. Since much of the investment is sunk anyway the first carrier to deploy fibre may have a significant competitive advantage. Although in some regions two or more operators are willing to invest, in other areas the fibre network will turn out to be a natural monopoly.

> *"In markets where facilities-based competition for next generation broadband access platforms proves unsustainable (or insufficiently robust), last-mile facilities*

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[17] New Zealand Institute (2007)

will remain a[n economic] "bottleneck." In such situations, policymakers will need to consider how best to regulate open access to bottleneck "last-mile" facilities. If there are inadequate facilities-based alternatives, then failure to ensure open access will pose a severe threat to competition in all of the upstream and downstream equipment and service markets that depend on access to a digital conduit between the home and wider-area network services."[18]

We can distinguish between three cases with regard to roll-out of fibre access networks. Different policies are necessary in these regions:

- No carrier is going to invest. In some geographical areas market forces will not suffice to upgrade the access network or deploy alternative technologies. If for political, economical or strategic reasons, an upgrade of the access network is deemed necessary, public intervention might be considered. This can come in various shapes – investment funds, investment by municipalities or other industries (e.g. developers or utilities).
- One carrier invests in fibre-optic access networks. Due to the significant sunk cost this carrier will have a competitive advantage (in absence of other opreators to use this infrastructure) which can also be a disadvantage if the operator would be subject to intensive wholesale regulation. In order to maintain competition in upstream and downstream markets an open access policy could be a useful policy to be implemented. In some regions (which might not be that small) copper is and will remain an enduring economic bottleneck.
- Two or more carriers build high speed access networks. In this case regulators only need to intervene ex-post in case of market failure.

5 Policy goals

5.1 Network- and service-based competition

From the regulatory perspective, there are mainly two possible ways of achieving the competitive level which is necessary for the benefit (the welfare) of customers: infra-

[18] Lehr, Sirbu, Gillett (2005)

structure-based competition (e.g. between different networks) and/or service level competition (e.g. based on one network).

Of course, there are hybrid models which are likewise possible. International studies and experiences show that for infrastructure-based competition (which necessarily requires at least two network operators) each network operator must be able to gain a certain market share in order to be profitable [Sadowsi, de Rooij, Smits, 2006]. Therefore it might be that a second operator would not be willing to deploy a fibre based access network, because a positive business case is not viable. Although infrastructure competition in general ensures the existence of competition in the best and most sustainable way, it may not always be viable, and thus here service-based competition as a "second best" option moves into the focus.

Based on this, regulation may mandate open access to these infrastructures. In its most abstract form, open access allows multiple competitors to share a bottleneck facility that is a critical input for the services that are provided to the customers. In most cases experienced in the regulatory environment so far, a bottleneck facility of this kind is owned by one of the companies that is also competing in the (downstream) retail business. The access is open if it is sufficiently non-discriminatory to allow all competitors to access the bottleneck facility under equivalent conditions – i.e. cost and quality terms. Only a non-discrimination obligation like this ensures that, if the bottleneck provider is competing in the retail market, it does not realise a significant competitive advantage by virtue of its ownership of the facility [Lehr, Sirbu, Gillett, 2005]. From the perspective of the customer, there is effective open access if the customer can choose to receive services from multiple providers offering services that could reasonably be considered substitutes, and if the customer's range of choice is not unduly constrained by the inability of competitors to obtain access services [Lehr, Sirbu, Gillett, 2005].

It is widely accepted that policymakers mandate open access rules to regulate access to the bottleneck facilities [Lehr, Sirbu, Gillett, 2005]. The open access rules may be introduced in different forms. At one extreme, regulators may rely on voluntary open access, under which the bottleneck owner is free to set the terms and conditions for access to the facility.

In general, non-facilities-based competition (or service level competition) in FTTH can occur in data-link layer (or transport) services via unbundled dark fibre (i.e. unbundled network elements) and in higher layer (voice, video and data) services via logical layer unbundling (or open access) [Banerjee, Sirbu, 2005]. FTTH architectures define the extent to which they support unbundling, and therefore the extent of non-facilities-based competition in FTTH depends on the architecture of the shared network via which multiple service providers offer their services. Different technologies imply different capital costs and different wholesale options.[19] Consequently, in deploying fibre to the home, a network operator may consider it unnecessary to adopt an architecture that enables physical plant unbundling, or may even be tempted to design the fibre architecture deployed in a way that eliminates the potential for future competition based on unbundled dark fibre elements, even at negotiated rates [Banerjee, Sirbu, 2005].

There is one additional layer (which may be labelled as level 0; see also Lehr, Sirbu, Gillett, 2005) in the form of corridors for the utilities (this including the corridors for the telecommunication infrastructure (i.e. ducts and cables)). Consequently, possible infrastructure competition will most probably be based on the wholesale of passive infrastructure (either the wholesale of the ducts, the cables or dark fibre) with the exception of those area in which the active services (e.g. lit fibre, bandwidth, etc.) are provided.

5.2 Investment incentives and the roles of the government

As the analysis of the demand side shows, there is significant need to move to next generation access networks. On the other hand the traditional players – like telecommunications operators are reluctant to invest. We have shown the main obstacles in chapter 4. In the next chapter we would like to explore possibilities to overcome the reluctance of the private sector to invest in next generation access. Thereby, we assume that the private sector incentive, especially for operators, given the uncertainties of the market and regulatory environment may not suffice to insert the optimal amount

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[19] See [Eurescom 2007]: Fibre in Access Network Greenfield Scenarios – Deliverable 2]: Techno-economic evaluation of PON and point-to-point Ethernet in green field scenarios; p. 20. See also [OECD 2008], p. 27.

of investment. If that is the case, and if these networks have a general public value, a subsequent consideration refers to the role of public policy.

The role of the government (we use this notion as representative of any type of public intervention and support) in the stimulation of the roll-out of state-of-the-art telecommunications networks can be in three ways.[20]

5.2.1 Government as stimulator

The role of a **stimulator** is defined here as removing the barriers that may impede the investment and roll out in new networks. In order to reduce the costs of rolling out and operating networks governments could facilitate:

- Establishing co-operation between the owners of multi-dwelling units and telecommunications companies with the goal to facilitate access by telecommunications companies to buildings. In France, for new buildings, there is an attempt to persuade building companies by providing a certification which indicates the presence of a fibre cable accessible to all operators in the basement of the building.

- Local governments or government-owned utilities often own ducts which cross under roads, etc. Granting access to these facilities to operators might decrease costs for building new networks, Furthermore, incentives by local municipalities to bring all utilities to the table to discuss rollout plans and possibilities to jointly construct part of the infrastructure can accelerate the deployment of at least the passive infrastructure and may also reduce costs for the different players.

- Decreasing costs of repaving, administrative fees etc. leveraged by the local governments. The city of Deventer in the Netherlands agreed to charge a lower

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[20] These roles are described in [OECD 2008], this chapter quotes the OECD document.

fee per meter for repaving on the condition that the network owners would arrange for the proper quality of repaving after the network had been rolled out.

- When building new neighbourhoods governments can incorporate the roll out of empty ducts throughout the site, together with other infrastructures, like sewers. This will allow easier access to customers for competing networks and might reduce the existing advantage of incumbent networks.

- Whenever governments open up roads and sidewalks for repair, providing new utility infrastructure, etc., they could allow network operators to add network infrastructure at minimal costs,

- When new networks are built governments can try to ensure greater co-ordination by operators to roll-out networks at the same time.

5.2.2 Government as producer

The role of **producer** is defined as actually investing in new networks. This implies that the government/the public involves itself with the financial obligation to enable the respective networks and to step in for the required financial means. Specific public funds to (co)-finance network rollout are tools which would follow these lines.

5.2.3 Government as regulator

The role of a **regulator** is limited to the government's role as a telecommunications regulator trying to guarantee a competitive marketplace. Some points that will need to be taken into account:

- **Business models** for new networks are sensitive to roll-out costs, population density, penetration rates and therefore show significant first mover advantages and a bias toward existing networks on a local level. This may result in a different competitive situation in different regions. In one area an existing network may have such an advantage that no new players will emerge, whereas in others there will be multiple competing networks, who compete effectively. In some regions a new entrant may quickly reach a large market share, leaving little room for existing players and becoming the incumbent "overnight". This will require regulators to balance national policies with local realities.

This is also stated in [OECD, 2008]:

"The impact of penetration rates on the monthly price for an all-fibre network is such that it is unlikely there will multiple networks to guarantee a competitive market. Even if we factor in existing cable and PSTN-based networks, it is unlikely that there will be enough room in the market place for four or more physical infrastructures to every household. For regulators this will mean that there is a continuing possibility of (tacit) collusion in the market."

- Providing **regulatory certainty** for network operators when they roll out new networks should focus on the success of the networks and not on the success of the services provided over those networks. Regulators should keep the provision of services open and competitive and not grant a monopoly on services when providing regulatory certainty for the investment in networks[21].

  As the OECD explains[22]:

  "Regulatory risk occurs when the regulator steps into the market in a manner unforeseen by the investors. This change might decrease the profitability of the Organisation and its investors. The change can be the result of a regulatory requirement on the network, but also of a regulatory requirement on a competitor that will benefit that competitor. Whether regulatory risk is a potential problem depends upon the chosen business model, the vulnerability of the business model to regulatory changes, the stability of the legal framework and its interpretation, the clarity given by the regulator and die conduct of the company (and its competitors) in the market place. A business model that is based on, or can change to an open access model will suffer less from regulatory risk from structural separation, unbundling or wholesale requirements."

OFCOM has addressed the issue of regulation for next generation access networks and sees its challenge as removing barriers to investment in NGA whilst maintaining

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21 This addresses the obstacle of regulatory uncertainty mentioned in chapter 4.2
22 See [OECD 2008]

effective competition. In its 2007 consultation, OFCOM proposed two parallel options for competition in NGA:[23]

- passive competition, where operators are required to open up parts of their physical infrastructure. For example, unbundling could be extended to street cabinets, allowing competitors to run fibre to the cabinet and use BT's copper to link into homes; and
- active competition, where the network operator sells a wholesale package that allows competitors to use its infrastructure to reach customers.

Regulation and technology are highly interrelated with respect to applying the “old” tools to a new technology. However, differences also exist compared to the background and regulatory policies of the past. In countries where policy serves to develop competition through facilities-based competition without any sharing of networks, the different topologies chosen to develop fibre networks may not create the need to make any changes to regulatory frameworks. The impact in those countries of the different network topologies may only be indirect in that different fibre topologies may have implications for the speeds which can be offered and the cost of providing service. In turn this may have an impact on the relative ability of a fibre network to compete with other technologies that may be close substitutes. In countries which have chosen to allow network sharing and unbundling as part of their policy framework in order to foster competition and reduce significant market power, the topologies of the networks have implications from a competition and policy perspective. This is because, as discussed earlier, different topologies have implications in terms of facilitating providers in sharing the network, for instance to facilitate wholesale broadband access and for local loop unbundling. New entrants, in countries supporting network sharing, will also be able to compete more effectively if action is taken to reduce entry costs, such as by setting wholesale prices for the incumbent’s ducts, or persuading municipalities to install large-capacity ducts when undertaking road works.

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[23] See postnote 305 (April 2008) by Parlamentary Office of Science and Technology, U.K.

5.2.4 General remarks on government intervention

One can look at possible government policies as supportive measures [OECD 2008, pp. 40], taking into account the issue of funding if the market cannot provide a solution. This policy – in our view – again raises the question of the long-term effects of interventions of this kind on the competition in the market. Some elements to be considered are:

> *"Regulatory interventions should be limited to the extent that they compensate for the market failure.*
>
> *When governments subsidise new networks or participate in public-private partnerships these should result in open networks that foster competition. It may be the case that a monopoly in the fixed infrastructure is unavoidable, but this should not lead to a monopoly either in wireless infrastructures built an top of this fixed infrastructure or in the provision of services over this infrastructure.*
>
> *Government's role in investing in physical infrastructures and provisioning services should be on a gradual scale with roughly the following steps:*
>
> *i) Digging trenches and laying ducts, removing a significant part of the costs of rolling out a network.*
> *ii) Providing passive network infrastructure to which network providers can connect their active infrastructure.*
> *iii) Providing an active network over which others can provide their services.*
> *iv) Providing services over the network to end-users.*
>
> *If governments are investing in networks and services, they should periodically evaluate whether there is still a necessity to do so and preferably state a fixed term at the start of the investment when the decision will be evaluated.*
>
> - *The business model of the network should not be made dependent upon the provision of services and network connections should be available separate to services.*
> - *A neutral and open network also requires a neutral and open interconnection point, where customers, network providers and service providers can connect to the network.*
> - *The network topology chosen for the network should be designed with competition in mind. A point to point network is therefore desirable over a PON-network.*

- *Governments should differentiate as little as possible between service providers and users of the network. Differentiation between users and service providers should reflect costs, efforts and service levels, allowing users to become service providers without an additional barrier.'*[24]

The Broadband Stakeholders Group has analysed models for efficient and effective public sector interventions in next generation access networks[25]:

- Demand side intervention: aggregation and stimulation
- Supply side intervention: procurement of a defined service
- Supply side intervention: public-private partnership
- Supply side intervention: utility business expansion
- Supply side intervention: working with property developers

The report also identifies critical success factors[26]:

- not pre-empting the market unless there are good grounds to do so
- using the open-access network model
- designing to minimise barriers to adoption
- stimulating and aggregating demand
- anticipating risks via detailed planning
- compliance with state aid rules, and support via other legal frameworks.

As can be seen, there are various ways and different intensities for public sector support to network rollout. The solution chosen depends strongly on local market conditions and demand. It also requires to find the right balance. Public sector support and especially funding should not crowd out private sector investment. This may be highly critical for the development of a competitive market in general. Therefore, "soft" measures as described above may foster network rollout and investment in a better way without implying biases for any business model or technology.

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24 OECD (2008a): Development in Fibre Technologies and investment, pp. 40.

6 Operational models

Infrastructure based competition has the advantage, that it creates a competitive pressure throughout the value chain. At the same time there is awareness, that in many respects it is not economically defensible to have parallel infrastructures.[27] This depends specifically on the geographical region. Some regions already enjoy competitive broadband infrastructures, while other areas are only served by one or no broadband provider.

The investment incentives to encourage a broadband access network have been described in chapter 5.2. Concerning service based competition, it is crucial which part of the network should be shared between operators. The majority probably thinks that it is natural and logical that ducts should be shared between competing actors. Ducts therefore do not have to be compulsorily exposed to competition. Probably the best solution for all parties is for excavations to be carried out only once, with competition-neutral ways of obtaining payment from competitors.

One level above ducts there is the cabling, e.g. fibre cable. In a number of areas a neutral party has laid out a sufficient quantity of fibre so that several different actors who lease fibre can share the same cabling. We can correspondingly discuss layer by layer, where in the infrastructure model it is more acceptable to have monopoly-like situations and where there is a requirement for competition. The higher in the structure model we get, the greater the prerequisites for competition. To that may be added geographical factors – the more densely the area is built up, with many customers, the stronger the arguments for establishing parallel, internally competing infrastructures.

> *Irrespective of where the line is drawn it is desirable that the actors who operate on one level in the value chain, where they have a monopoly, should maintain neutrality. The customer of such an actor must feel confident that there are equal conditions of competition, i.e. that the price will be set by the market, that it is cheaper and better to lease from this neutral party than to establish an infrastruc-*

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[25] see BSG (2008)
[26] see also DTI, OFCOM (2007)
[27] July 2005 SOU 2005:97 När en räcker: mastdelning för miljön (When one is enough: mast sharing for the environment)

ture of one's own, that the supervisory authority has predictable means to deal with new actors on the market and so on.

We found that it was precisely the dividing line between monopoly and competition, and the actions and effects of the various in different market situations, which were the critical questions for IT policy. They influence not only the development of IT infrastructure but also the development of services, competition and innovation as well as the ability of consumers (private persons, the public sector, etc) to access the services they desire, independent of time and place."

These arguments have led us to the concept of operational models. The operational models refer to the split between monopoly like behaviour and sustainable competition. In our opinion, one can look at the stepwise "ladder" which may refer to the different activities needed to set up infrastructure for telecommunications purposes and offer services. This ladder starts with the availability of rights of way for the deployment of infrastructure, followed by the availability of ducts to allow fixed telecommunications infrastructures to be set up/space to be made available, for example to allow wireless operators to set up their station and antennae, followed by the provision of the physical transmission medium which can come in the form of "unlit fibre", or can be comprised of "lit fibre", with the fifth step being the provision of services. This type of differentiation between the operational models can be demonstrated graphically in Figure 7:

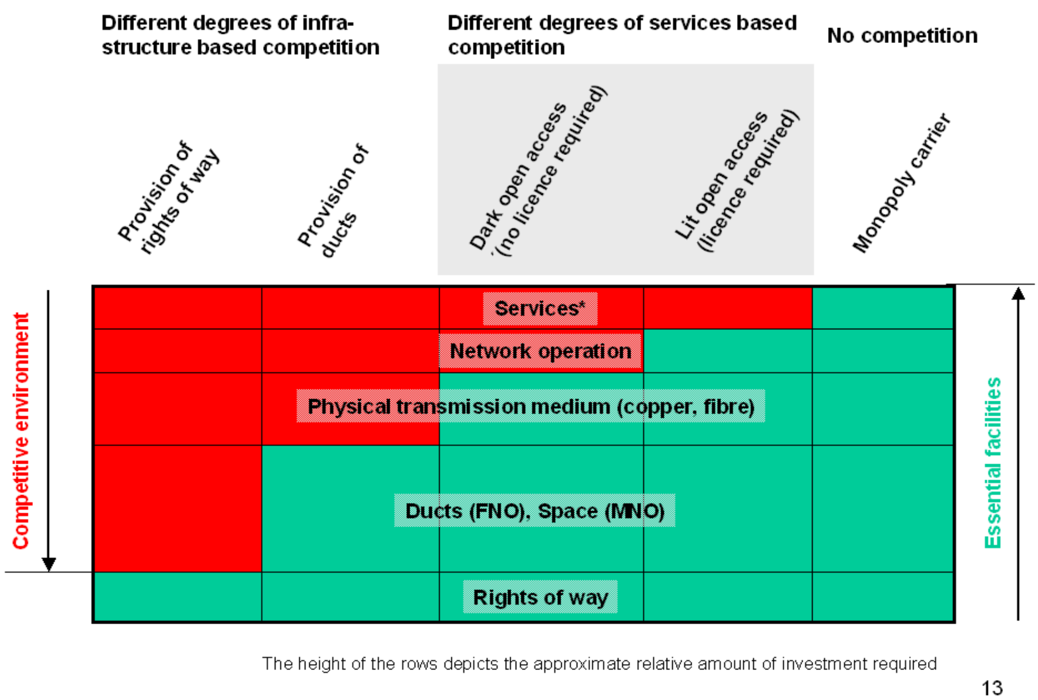

Figure 7: Operational models

At this stage it can be stated that the features and characteristics of the operational models relate to regulatory characteristics/regulatory approaches. Liberalisation of telecommunications networks started with the operational model on the right hand side. The political and economic goal is to reach the left hand side model, which refers to infrastructure based competition.

- **Corridors are provided by the land owner – the telecommunications operator provides ducts, physical transmission (cable) and services**
  In this model the service corridors are provided. Operators can provide their own infrastructure. There is however the risk that no operator puts in infrastructure. Additionally this might lead to very inefficient use of investment.

- **Ducts are being provided by the developer or the municipality and shared between different users – the telecommunications operator provides physical transmission (cable) and services**
  Operators rent or buy ducts from the developers or the municipalities. Therefore no economic replicability of ducts is assumed. Rules need to be in place for non-discriminatory and equal access to these ducts on fair terms.

- **Cables are provided by the developer or the municipality – the telecommunications operator provides services**
  In this operational model also cables are provided in a monopoly like manner. This infrastructure is handled as other utilities and wholesale services are offered on a non-discriminatory, equal and fair basis to other operators. This approach has been called “wholesale model” in our overview of operational models and can come in two different sub-forms due to the fact that the developer could offer the cables “dark” or “lit” (see below).

- **A monopoly like solution**
  This includes the provision of passive and active elements and the services. This option involves some kind of exclusivity in return for investment infrastructure. The underlying assumption is, that telecommunications networks and services are not economically replicable and need to be provided by the public. It is today generally recognized that this is not the way to go. At least service provision should happen in a competitive environment.

All of these models assume however that at least one infrastructure is already in place. In the case of next generation access networks we are facing a situation where no infrastructure is available. In order to apply the regulatory approaches mentioned above investment incentives for at least one player need to be available. These investment incentives are highest in the monopoly carrier model. The disadvantage is that the goal of competition is not fulfilled. From a regulator's point of view regulatory holidays seem unlikely so that a player going this way faces the problem that he might build a structure which will be opened up in the same way as incumbent carriers' at the end of the 1990s. It comes as no surprise that there is much reluctance to invest. The models described above also refer to "owner" and "municipality". Whereas the municipality clearly is an element of the "public", owners may be public or private owners. However, even in case of private owners one can argue that their overall responsibility for e.g. a certain facility puts them in the place of a "quasi-public" institutions which should take care and responsibility of the development and value of the facility.

A balance needs to be struck between competition – which is best fulfilled with the model on the left hand side and incentives for investment – which is best fulfilled by monopoly, the model on the right hand side. The optimal solution might vary for different regions and different stages of the market evolution. The goal is to move as far to the left as possible provided more than one player invest in state-of-the-art infrastructure. The part of the network with monopoly like behaviour needs to be opened up by applying an open access policy. A further argument to consider is that the higher the requirements for infrastructure – or put another way – the more capital expenditure is needed, the more monopoly like the structure will appear. Since demand is derived from the general public, the government has means and an obligation to step in and move the model to the left hand side by taking some kind of investment risk and offering it via open access.

We conclude that different forces are at work which determine the optimal model. Technological evolution will lead to decreasing prices, which eventually will allow a deeper level of competition. Surfacing concrete demand and willingness to pay also will lead to increased incentives to invest. The government has the means and responsibility to influence the models in order to achieve the optimal balance between competition and investment by also considering the public value of state-of-the-art telecommunications. Such an influence could be used by determining which types of models will be accepted from a regulatory perspective as they contain the possibility to achieve competition AND investment in parallel.

7 Conclusions

We derive the following conclusions:

- State-of-the-art telecommunications infrastructure involves fibre deployment in the access network, because this is the only medium suitable for offering future-proof bandwidth.

- International experience shows that reliance on the telecommunications market with its competitive nature might not be sufficient to achieve this state-of-the-art infrastructure. From an economic point of view, an evolved last mile which does no longer constitute a technical bottleneck will still represent an economic bottleneck. This is backed up by the fact that all successful models mentioned above involve funding models, which also involve other stakeholders such as developers or state/municipal government.

- The move from monopoly to competition and technological acceleration have implied a large degree of uncertainties which may be lead to sub-optimal amount of infrastructure investment.

- Alternative funding models of this kind can involve private or public investment. OECD mentions the possible roles of the government [OECD 2008, p. 36] which would have an impact on "production" besides its role as stimulator and regulator.

- Non-facilities based competition needs to be based on an open access policy.

- Full infrastructure competition in fibre networks may not be realized only through market forces. Therefore, public intervention and support may be helpful to overcome the reluctance to invest. Such support should be technology and competitively neutral. Therefore, our main finding is that for fibre infrastructure to be implemented, markets AND institutions have an important role to play.

Concluding we would like to state that competition and investment represents some kind of dichotomy. This means that a balance needs to be struck between these two conflicting goals.

References

BANERJEE, Sirbu (2005): Towards Technologically and Competitively Neutral Fibre to the Home (FTTH) Infrastructure. http://itc.mit.edu/itel/docs/2003/banerjee_sirbu.pdf

BRANDL Margit, WIECK, Reinhard (2008): Can Regulation Forster Investment or not? An operator's and manufacturer's point of view, ITS conference Montreal July 2008, http://www.itsworld.org

BROADBAND STAKEHOLDERS GROUP (2008): Models for efficient and effective publicsector interventions in next-generation broadband access networks, Report by Analysys Mason ltd. Commissioned by BSG, 9 June 2008

CRANDALL Robert, LEHR William and LITAN Robert (2007): The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data. Issues in economic policy, the Brookings Institutions. Number 6, July 2007.

CRANDALL Robert: Through a Looking glass dimly, Future Issues in Telecom Regulation, ITS conference Montreal July 2008, http://www.canavents.com/its2008/plenary3/10.pdf

DTI, OFCOM (2007): Public broadband schemes – a best practice guide

ELIXMANN Dieter, MARCUS Scott (2008): International Regulatory Comparisons, The Evolution to IP-Based Fibre, ITS conference Montreal July 2008; www.itsworld.org

EURESCOM (2007): P1651 (FANGS): Fibre in Access Network Greenfield Scenarios

EUROPEAN COMMISSION:
- (2005): COM(2005) 229 final: i2010 – A European Information Society for growth and employment
- (2006): COM(2006) 129 final: Bridging the broadband gap
- (2008a): COM(2008) 153: 13th progress report on the single European electronic commmunications market.
- (2008b): COM(2008) 199 final: Preparing Europe's digital future - i2010 Mid-Term Review

FORFAS (2006): Overview of Irelands broadband performance, November 2006

ITIF (2008): Explaining International Broadband Leadership, The Information Technology and Innovation Foundation, May 2008.

LEHR, OSORIO, GILLETT, SIRBU (2006): Measuring Broadband's economic impact.

LEHR, SIRBU, GILLETT (2005): Broadband Open Access: Lessons from Municipal Network Case Studies. http://itc.mit.edu/itel/docs/2004/Broadband_Open_Access.pdf

NEMERTES (2007): The Internet Singularity, Delayed: Why Limits in Internet Capacity Will Stifle Innovation on the Web; produced by Nemertes Research, Fall 2007.

NEW ZEALAND INSTITUTE (2007):

- Delivering on the broadband aspiration: a recommended pathway to fibre for NZ (2 April 2008)
- Assessing New Zealand's current broadband path: the need for change (12 March 2008)
- Defining a broadband aspiration (26 September 2007)
- A broadband strategy for New Zealand (5 September 2007)

NOAM Eli M. (2007): State of Telecom 2007, CITI conference 19. October 2007 http://www4.gsb.columbia.edu/citi/events/eventsarchive/stateoftelecom2

OECD
- (2008a): Developments in fibre technologies and investment, http://www.olis.oecd.org/olis/2007doc.nsf/LinkTo/NT00005E06/$FILE/JT03243516.PDF
- (2008b): Public rights of way for fibre deployment to the home http://www.olis.oecd.org/olis/2007doc.nsf/LinkTo/NT00005E12/$FILE/JT03243586.PDF
- (2008c): Broadband portal. http://www.oecd.org/sti/ict/broadband

OFCOM (2007): Future broadband - Policy approach to next generation access; consultation published 26 September 2007.

SADOWSI Bert M., Marc de Rooij, Jan Smits (2006): State aid, open access and market size: two cases of FTTH network implementation in Dutch municipalities

TFI (2005): Forecast for higher bandwidth broadband services; quoted in http://www.tmcnet.com/tmcnet/articles/2005/broadband-ip-video-higher-bandwidth-forecast-technology-futures-vanston.htmTHOMPSON, Herbert Jr. (2008): Broadband Impacts on State GDP: Direct and Indirect Impacts, ITS conference Montreal July 2008; www.itsworld.org.