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Ernst-Olav Ruhle* and Wolfgang Reichl**

Incentives for Investments in Next Generation Access and Customer Choice: a Dichotomy?

*According to Noam,[1] "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". Investment in next generation access network is needed to deliver broadband services with significantly higher bandwidth than today. This will allow the development of more innovative and better services. Investments under competitive conditions require a positive business case, which might not be viable for long-lived assets like fixed access networks. This might lead to the situation where we can only have competition **or** a next generation access network but not both. This paper looks at the aspects of investments in next generation access (NGA) networks and competition and specifically focuses on potential effects of the EU commission draft recommendation on NGA.*

How to decide about investment in a competitive environment 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 demand for very high bandwidth cannot be delivered via the existing copper plant. Additionally, for incumbent operators (but also for some new entrants) the question of regulation of NGA is a cornerstone of their investment decisions.

Since employment and economic growth are closely correlated with broadband penetration, the topic of upgrading the access network is now becoming more and more important. Private sector investment is preferable from an economic point of view, but whether it will materialise depends on the existence of a positive and sustainable business case. Therefore a balance needs to be struck between incentives for investment and securing competition in telecommunications. In our opinion, this requires cooperation between the private and the public sector. Furthermore, the regulatory environment is crucial to give the right signal to current and future new market players with respect to what they can expect in terms of access regulation. With its recent draft recommendation[2] on NGA the EU commission has given a flavour of potential measures. The possible effects of this recommendation will be assessed in this paper.

Bandwidth Issues

The ever increasing demand for more bandwidth can only be met by advanced broadband transmission technologies. Today we are considering xDSL, coaxial cable and fibre optic cables as fixed network broadband delivering technologies. Figure 1 shows the broadband penetration in OECD countries by technology used.[3]

There is no universally agreed definition of broadband and the required size of the bit-pipe depends on applications. If more bandwidth is available, it will be used in existing applications changing the users' perception of broadband. Higher bandwidth will also generate entirely new applications. The definition of broadband is time-sensitive. What was regarded as

* CEO of SBR JUCONOMY Consulting, Düsseldorf, Germany.

** CTO of SBR JUCONOMY Consulting, CEO of SBR JUCONOMY Consulting, Vienna, Austria.

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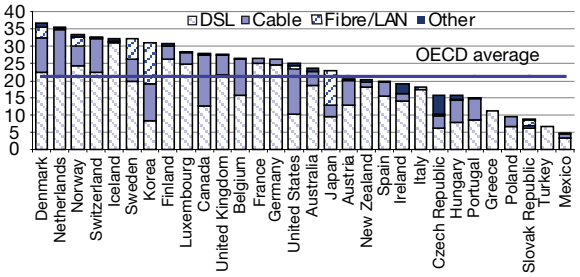
[1] Cf. Eli M. Noam: State of Telecom 2007, CITI Conference 19 October 2007, http://www4.gsb.columbia.edu/citi/events/eventsarchive/stateoftelecom2.

[2] Draft Commission Recommendation of … on the regulated access to Next Generation Access Networks (NGA) and Commission staff working document explanatory note, Accompanying document to the commission recommrndation of … on regulated access to Next Generation Access Networks (NGA), 2008, http://ec.europa.eu/information_society/policy/ecomm/library/public_consult/nga/index_en.htm.

[3] Cf. OECD broadband portal - http://www.oecd.org/sti/ict/broadband. The total number of broadband subscribers in OECD countries in June 2008 was 251 million. The European Commission reports nearly 100 million broadband lines on 1 January 2008.

Figure 1
OECD Broadband Penetration, June 2008



broadband yesterday may be far away from broadband today and even further away from broadband tomorrow.[4] Recent studies underline the growing Internet traffic in the backbone if access is based on fibre, although predictions of bandwidth shortages in the backbone seem unfounded, as has been shown in recent case studies.[5]

Demand for broadband not only comes from the end-users but is also derived from other segments of the industry (because the Internet is regarded as a multi-sided market). State-of-the-art telecommunications infrastructure in general and broadband in particular are widely regarded as necessary prerequisites for economic growth which implies a strong interest of the general public in network modernisation.[6]

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

The telecom market has moved from monopoly to competition at all levels of the value chain including infrastructure. Network rollout and the massive investments have to be financed by revenues from competitive business fields and not by inherited rents as was the case in the past. This may lead to reluctance to invest under uncertain payback conditions – especially for companies which are actually or potentially regulated and would have 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 the expenditure. 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 goods. As mentioned above, access infrastructure is expected not only on the consumer side but also – even more – by enterprises. As many sectors of the economy and indeed society as a whole benefit from next generation access infrastructure, the question arises whether the public should pay for at least part of the infrastructure. The incentives for investment by the "usual suspects" (i.e. the telecommunications industry) are rather weak. The question of the public financing of broadband networks has received increasing attention over recent months in light of the negative economic outlook for 2009. It is being discussed as a tool to support the economy via public investment in infrastructure as well as for other purposes (universities, schools etc.)[7]

Current Access Networks

Copper based access networks were built by the incumbent network operators and financed in a monopoly environment. Since liberalisation was introduced, investments in the access network have developed at a moderate level in terms of extending the network (although some upgrading (e.g. by DSL) and operation and maintenance has taken place), and strategy has focussed on the exploitation of existing assets. In principle, despite DSL investments, the existing networks are still largely based on copper technology imple-

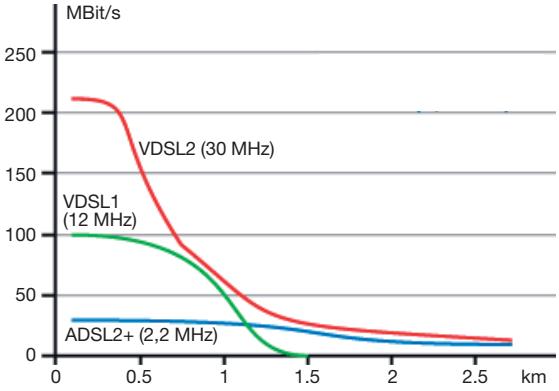
[4] See the discussion on ultrabroadband networks as discussed in Robert C. Atkinson: Market Structure for Ultrabroadband, Communications & Strategies, Special Issue Nov. 2008; Raul L. Katz: Ultrabroadband Investment Models, Communications & Strategies, Special Issue Nov. 2008.

[5] Cf. Kenjiro Cho: Observing Slow Crustal Movement in Residential User Traffic, JAPAN_kjc-conext2008.pdf; and http://www.ams-ix.net/technical/stats/, which shows that the Amsterdam Internet Exchange has broken the 500 Gbit/s barrier (one year after the 300 Gbit/s barrier).

[6] Cf. Lars-Hendrik Röller, Leonard Waverman: Telecommunications Infrastructure and Economic Development: A Simultaneous Approach, in: American Economic Review, December 2001; BMWi: Gesamtwirtschaftliche Auswirkung der Breitbandnutzung, Studie MICUS, March 2006; Connected Nation: The Economic Impact of Stimulating Broadband Nationality, February 2008; Californian Broadband Task Force: The State of Connectivity – Building Innovation through Broadband, January 2008; Nemertes Research: The Internet Singularity, November 2007.

[7] The topic has also been of relevance with respect to the recent elections in the USA. "Obama and Biden believe we can get true broadband to every community in America through a combination of reform of the Universal Service Fund, better use of the nation's wireless spectrum, promotion of next-generation facilities, technologies and applications, and new tax and loan incentives." Cf. "Deploy Next-Generation Broadband" at http://www.barackobama.com/issues/technology/.

Figure 2
Bandwidth vs. Distance for Various DSL Technologies[1]



[1] http://www.elektronik-kompendium.de/sites/kom/0305236.htm.

mented decades ago. The natural consequence is that different digital subscriber line (xDSL) technologies are used in the existing local loop instead of replacing copper wires with high-grade conduit. However, it needs to be considered that expectations for the introduction of access technologies with large bandwidths in short time-frames are high, whereas VDSL rollout would take considerable time considering the fact that fibre would have to be rolled out to many street cabinets.

While ADSL can be deployed from the central office, VDSL2 – allowing higher speeds – requires a hybrid network, consisting of fibre and copper. As Figure 2 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 instead of ADSL, because it does not offer superior bandwidth.

Copper-based access – already an economic bottleneck – is becoming a technical bottleneck as well. This faces a massive constraint, though. Copper access networks were established in times of monopoly. Justifying this investment in a monopoly situation with growing demand was easy. After competition is introduced, investments are more critical. Incumbents become more prudent as they would like to avoid making investments which pave the inroad for new competitors via regulation. New entrants, on the other hand, will focus their business approach on attractive market segments with quicker and less risky remuneration. However, broadband is an essential utility for the information society and requires access networks capable of handling the growing bandwidth. Therefore a delicate balance has to be struck between investment incentives and competition. The technical characteristics of fibre may carry a tendency to restate the access monopoly – dependent on the market conditions in specific locations. So, access based on fibre could also become an economic bottleneck again.

The political goal, however, is infrastructure-based competition. Alternative technologies in access networks are cable networks and wireless solutions. Today, both technologies display technical constraints. Coaxial cable is only available in specific regions while wireless is not deemed capable of providing the same bandwidth as wired technologies economically.

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 meet demand for higher network capacity. Candidate technologies are wireless, cable and fibre.

The cable network uses a mixture of optical fibre and coaxial cables. The coverage of cable networks is usually much lower than that of copper access. The bandwidth offered is up to 300 Mbps with the new DOCIS3.0 standard. The bandwidth of cable broadband does not decrease significantly with distance, but bandwidth is shared by all users connected to one strand.

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 LTE (Long Term Evolution) will increase this up to 100 Mbps. These technologies will require additional radio spectrum but the bandwidth per base station is also shared by all users connected.

It is generally agreed that the most future-proof option for broadband access is laying new optical fibre cables. These optical fibres 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 today, but extending them into the access network is costly. There are different options for fibre deployment:

- fibre to the home (FTTH), where each customer has a dedicated fibre coming from the exchange into the home, providing very high bandwidth and reliability;

- passive optical network (PON), where passive components (optical splitters) are used within the access network, lowering the maintenance cost compared with the deployment of active components;
- active star, where active components (routers) are placed into the network, allowing concentration of fibre cables;
- fibre to the cabinet (FTTC), where fibre runs from the exchange to street cabinets and the existing copper line (using, for example, VDSL) is used for the final link into the premises. This is cheaper than FTTH, but new equipment must be installed in street cabinets, maintenance costs and power consumption increase and reliability might be reduced.

The introduction of optical fibres into the access network is expensive because of civil engineering costs, and it is only being undertaken by a few operators on a large scale (e.g. Verizon, NTT DoCoMo and Korean Telecom) but also by some municipalities and cities in Sweden and the Netherlands. The cost of fibre deployment can be segmented into four parts which are (1) conduits, fibre optic and the infrastructure; (2) active network components; (3) customer premises equipment; (4) costs of operation and maintenance of the network.

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 therefore the results might not be exactly comparable, a number of conclusions about the roll-out of fibre can be drawn:

- Civil engineering (digging trenches and installing subsoil ducts up to the buildings) is the single largest cost item in an FTTH network deployment.[8]
- Infrastructure and civil engineering costs make up between 60% and 80% of fibre deployment, most of it needed to establish cable ducts. The cost of the cable itself is only about 6%.[9]
- There is no significant cost difference between deploying fibre cables and developing new copper cables.
- Best practice cases for the cost of fibre deployment in urban areas result in around €1000 per home connected.[10] Prices have been decreasing over time.
- Considering the cost of the chosen architecture, the overall costs of PON deployment are in general 20% less than active star or home-run fibre, as EURESCOM has found out in a techno-economic evaluation of PON and point-to-point Ethernet in greenfield scenarios.[11]

Compared with fibre optic cables in the access, wireless technologies will play a role for users or applications that require less bandwidth or in less populated areas. In cable networks the shared part of the network needs to be reduced, which leads to increasing deployment of fibre in the local loop.

Given the importance of broadband, two questions arise:

- Will the market forces suffice to provide fibre-based access network? Furthermore, will all areas be covered or just selected spots in densely populated areas, where demand is regarded as sufficiently high?
- If fibre-based access networks are rolled out, will sustainable competition be possible? A simple calculation shows that the given cost of €1000 per home passed and an ARPU of €30, the amortisation period will be about 9 years provided there is a 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 to regain investment costs increases significantly.

This might lead to the conclusion that network roll-out costs need to come down in order to allow competition in access networks. On the other hand – given the importance of broadband for the 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.

Obstacles to Investment

Traditionally telecom operators have been responsible for the provision of access networks. However, these networks have been rolled out under monopoly

[8] Cf. Gabrielle Gauthey: Broadband Infrastructure – Points of Reference and Outlook, at the Global Forum, November 2007, ARCEP 2007. Cf. also OECD: Public rights of way for fibre deployment to the home, http://www.olis.oecd.org/olis/2007doc.nsf/LinkTo/NT00005E12/$FILE/JT03243586.PDF.

[9] Cf. Gabrielle Gauthey: Next Generation access networks and net-neutrality, IDATE Transatlantic Telecom Forum, November 2007; Ian Grant: Ofcom to let BT set down prices for fibre broadband, ComputerWeekly.com, September 2008.

[10] Cf. D. van der Woude: An overview of Fibre – European FTTH and Fibre backbone projects, 3rd edition, November 2007; A. Banerjee, M. Sirbu: Toward Technologically and Competitively Neutral Fibre to the Home (FTTH) Infrastructure, November 2004, http://itc.mit.edu/itel/docs/2003/banerjee_sirbu.pdf.

[11] Cf. Eurescom: P1651 (FANGS): Fibre in Access Network Greenfield Scenarios – Deliverable 2: Techno-economic evaluation of PON and point-to-point Ethernet in green field scenarios, 2007.

conditions. One might also say that access networks have been built up under a regime of public governance and, due to the public good character of the network, the public might be held responsible for access networks. Access networks were for a long time assumed to represent essential facilities and thus bottlenecks which could not be duplicated. We see new networks being established now; however, again the discussion arises whether e.g. fibre to the home networks will be established by several operators in the same location. If not, this could be a sign of such networks being enduring bottlenecks. Additionally, bottlenecks tend to initiate regulatory action with respect to access. Such regulation impacts the willingness to invest. In the current situation of regulated competition (at least for current generation access networks but also increasingly for next generation access networks), telecoms operators are reluctant to invest in next generation access networks.[12] Obstacles can be grouped into two main categories:[13] market uncertainty and regulatory uncertainty.

Market Uncertainty

Market uncertainty comprises two aspects: uncertainty on the demand side ("*demand uncertainty*") and uncertainty on the supply side ("*investment uncertainty*"). The first aspect refers to the difficulty for telecommunications operators of assessing the demand for a product which does not yet exist. 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 to invest in long-lived assets like fibre-optic cables. Therefore, investment uncertainty could arise as an obstacle resulting from demand and regulatory uncertainty.

Whether deployment of 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 means that the potential private value to be gained by investors is comparatively weak. Considering this gap, the current infrastructure, and planned investment in this infrastructure, may not be sufficient to match the demand for bandwidth in the medium to long term. This requires us to consider the responsibilities of the parties involved for investments in next generation access networks to overcome this gap.

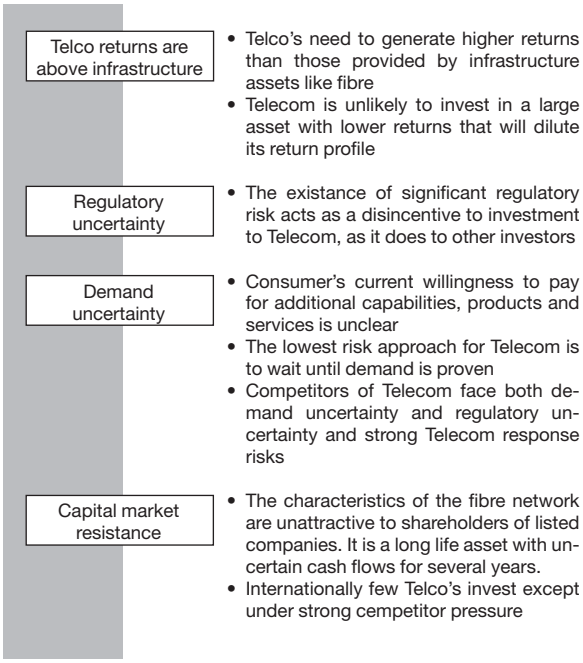
Regulatory Uncertainty

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 undertaken to the same extent as under well defined and communicated regulatory frameworks. 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 against service-based competition due to the advantages that can be achieved. However, to establish this type of competition a longer period of time is usually necessary. Service-based competition may therefore have advantages in the short term. Looking at other regions, it can be concluded that the EU e.g. 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.

[12] Cf. P. Heinacher, B. Preissl: Fiber-Optic Networks: On investment, Regulation and Competition, in: CESifo DICE Report 3/2006, pp. 22.

[13] The authors have conducted a study for the Telecommunications Regulatory Authority in Bahrain. This study (http://www.tra.org.bh/en/pdf/Juconomy-TRA-Bahrain-Final_report.pdf) examines the obstacles to investment in telecommunications networks and services in new developments.

Figure 3
Obstacles to Investment
Telecom Faces Weak Incentives to Make Significant Investments in the Fibre Access Network



Source: The New Zealand Institute: Assessing New Zealand's Current Broadband Path: The Need for Change, March 2008, http://www.nzinstitute.org/images/uploads/Assessing_NZs_current_broadband_path.pdf.

At the same time the duplication of infrastructures is an economic concern as the duplication could lead to inefficient investment and inefficient market entry which would harm all market players.

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. Other analyses also show a similar summary of the reasons for uncertainty on the part of the operators (cf. Figure 3).[14]

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 overcompensate this risk by reaping the benefits from being the first mover on the market. 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 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."[15]

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, economic 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. Despite significant sunk costs this carrier will have a competitive first-mover advantage (in absence of other operators to use this infrastructure and if no infrastructure sharing is enabled for potential competitors) which can also be a disadvantage if the operator were 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 the case of market failure.

The Draft EU Recommendation on NGA: More or Less Regulatory Uncertainty?

The first signs of more clarity on the way regulation will address NGA are visible. In September 2008, the EU commission published a draft recommendation with respect to the obligations of SMP operators on the markets for wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location and wholesale

[14] New Zealand Institute: 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.

[15] W. Lehr, M. Sirbu, S. Gillett: Broadband Open Access: Lessons from Municipal Network Case Studies. http://itc.mit.edu/itel/docs/2004/Broadband_Open_Access.pdf.

broadband access, which are markets 4 and 5 according to the recommendation on geographic and service markets to achieve a consistent regulatory framework throughout Europe for access to NGA networks.[16]

The goal is to define potential access remedies which ensure a competitive framework for retail products on the basis of NGA. To that end, the recommendation foresees that national and regional (geographic) market definition and delineation can be applied. With the draft recommendation regulators are motivated to apply extensive remedies such as:

- access to existing and new ducts and manholes, whereby sufficient capacity shall be made available to requesting network operators (access seekers)
- access to passive network elements and optical fibre
- access to street cabinets or its "optical equivalent", i.e. the equivalent element in a fibre access network.

Regulatory authorities are requested to enable and foster projects for the joint establishment and usage of infrastructures by SMP operators and alternative operators. Also, the non-discrimination principle shall remain applicable to SMP operators for the NGA environment. Remedies already levied upon SMP operators in the current generation access network environment shall remain in place independently of changes in the network topology.

Regulatory authorities shall furthermore ensure a reasonable migration path in order to allow alternative operators to adapt to the NGA developments. When regulatory authorities determine the costs of access to NGA infrastructures a Return on Capital Employed approach (RoCE) is to be applied which considers a reasonable and project specific risk premium. The calculation of the risk premium is further detailed in an annex to the draft recommendation. On the other hand, the commission proposes that there should be no unreasonable remedies regarding access to wholesale products if the downstream retail market can be regarded as an "emerging market".

The publication of reference offers for access to wholesale products shall be obligatory due to reasons of transparency and contain the conditions for:

- access to ducts and manholes as well as network elements and fibre optics
- information on the length and capacity of ducts.

SMP operators shall make available information about their future network rollout plans in order to allow for consistency in planning and coordination of the investment of alternative operators.

The commission further details proposals with respect to specific types of network design and rollout:

- for FTTH the commission takes the view that regulators shall enable and foster joint infrastructure rollout especially for in-house networks;
- for FTTH the draft recommendation proposes that regulators may levy further remedies on top of access to ducts such as access to dark fibre, in case technical, physical or economic reasons do not allow for access to ducts;
- for FTTH the commission advises the national regulators to levy reciprocity with respect to obligations, i.e. the obligations upon the SMP operator become void if the competitors do not offer reciprocal access to their NGA elements;[17]
- access to (fibre) sub-loops at street cabinets of the SMP operators shall also be integrated in the set of obligations.

Regulators are also asked to make sure that with respect to the substitution of copper based networks a migration path can be agreed between SMP operators and access seekers:

- for an FTTC environment co-location at street cabinet level or in proximity to street cabinets shall include ancillary services (such as e.g. power supply).

The introduction of NGA services overall may not be detrimental to broadband offers of alternative operators which currently use unbundled local loops. The commission also requests that the design of access products must allow all parties the migration to FTTH.

Bearing all this in mind, one could evaluate the currently very different approaches and activities of alternative network operators with respect to the rollout of new networks. The main question is whether any specific network topology or investment model is favoured by the draft recommendation of the commission. Table 1 summarises the results by assessing for different models (column 1) the results of the assessment of the implications of the draft recommendation on such a business model (column 2). It also lists the conclusions of these models from the perspective of

[16] http://ec.europa.eu/information_society/policy/ecomm/library/public_consult/nga/index_en.htm.

[17] This implementation may be difficult to achieve as it implies an obligation upon non-SMP operators. It should be clear, though, that this proposal is about reciprocity of access and not reciprocity of fees.

Table 1

Impact of the Draft NGA Recommendation of the EU Commission on Alternative Operators

Business model	Assessment	Conclusions from a new entrant's perspective
FTTH – PON	Favourable conditions for access to legacy ducts. Less favourable for new ducts. Essential wholesale service which is reasonable where the incumbent already has infrastructure in place	Relatively advantageous in areas with existing (legacy) ducts.
FTTH – P2P	Favourable conditions for access to legacy ducts. Less favourable for new ducts.	
FTTB	Favourable conditions for access to legacy ducts. Less favourable for new ducts.	
FTTC-VDSL	Favourable conditions as all wholesale services are supposed to be regulated on LRIC basis.	These models would receive favourable treatment with respect to price regulation for wholesale. However, strong dependency on offers of incumbent and decision of NRA.
Bitstream Access	Favourable conditions as all wholesale services are supposed to be regulated on LRIC basis.	
CATV networks	No dependency on wholesale services of the incumbent. Deviation from LRIC regulation for NGA elements may be favourable for cable network operators	Attractive, as deviation from LRIC may foster the cable networks' business case (and no dependency on wholesale products).

an alternative network operator requesting wholesale services (column 3).

The following conclusions can be drawn:

- FTTH and FTTB as business models are "favoured" by the draft recommendation for situations where ducts of the SMP operators are already available. In other areas operators pursuing these business models are forced to contribute to the costs of the incumbents indirectly.
- FTTC rollouts will in general be offered at an "advantageous" price in comparison with other wholesale products and business models as an LRIC standard is to be applied.
- Cable networks are largely independent of the access wholesale markets. Due to the fact that in a number of cases the LRIC standard is no longer supposed to be the basis for cost calculation and due to the fact that risk premiums are considered for certain wholesale products, it seems that CATV networks improve their position in the market relative to other network rollouts.

Policy Goals

From the regulatory perspective, competition can be achieved at two levels:

- infrastructure-based competition (e.g. between different networks)
- service level competition (e.g. based on one network).

Of course, there are hybrid models. International experience shows 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.[18] 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 achievable, and thus service-based competition as a "second best" option moves into focus.

Based on this, regulation may mandate open access to existing 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, 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 non-discriminatory, i.e. all competitors are granted access to the bottleneck facility under equivalent conditions in terms of cost and quality. 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.[19] 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.[20]

[18] Cf. B. M. Sadowsi, M. de Rooij, J. Smits: State aid, open access and market size: two cases of FTTH network implementation in Dutch municipalities, 2006.

[19] Cf. W. Lehr, M. Sirbu, S. Gillett, op. cit.

[20] Ibid.

It is widely accepted that open access rules regulate access to bottleneck facilities.[21] They may take on 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 a data-link layer (or transport) services via unbundled dark fibre[22] (i.e. unbundled network elements) and in higher layers (voice, video and data) via logical layer unbundling (or open access).[23] FTTH architectures define the extent to which they support unbundling. 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.[24] 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.[25]

There is one additional layer (which may be labelled level 0[26]) in the form of corridors for the utilities (i.e. mainly ducts and cables). Consequently, possible infrastructure competition will most probably be based on the wholesale of passive infrastructure (either wholesale offers of ducts, cables or dark fibre) with the exception of those areas in which the active services (e.g. lit fibre, bandwidth, etc.) are provided.

Investment Incentives and the Roles of the Government

The analysis of the demand side shows that there is a significant need to move to next generation access networks. On the other hand, the traditional players – such as telecommunications operators – are reluctant to invest. Below, we shall explore possible ways to overcome the reluctance of the private sector to invest in next generation access. We assume that in the private sector incentives, especially for operators, (given the uncertainties of the market and regulatory environment) may not suffice to induce the optimal amount of investment. If this is the case, and if these networks have a general public value, policy intervention has to be considered.

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 take three forms.[27]

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 cooperation between the owners of multi-dwelling units and telecommunications companies with the goal of facilitating 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 for different types of utilities (electricity, gas, water, sewerage 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 possible ways 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.
- When building new neighbourhoods governments can incorporate the roll out of empty ducts throughout the site, which can be jointly used by other infrastructures, such as sewers. This will allow easier access to providers of competing networks and

[21] Ibid.

[22] This refers to the concept of making available a pure dark fibre link (not bundled with equipment or services) by the infrastructure provider to another provider of electronic communications networks or services who connects equipment in order to be able to transmit information on that link.

[23] Cf. A. Banarjee, M. Sirbu, op. cit.

[24] Cf. Eurescom, op. cit., p. 20. Cf. also OECD: Developments in fibre technologies and investment, http://www.olis.oecd.org/olis/2007doc.nsf/LinkTo/NT00005E06/$FILE/JT03243516.PDF, p. 27.

[25] Cf. A. Banarjee, M. Sirbu, op. cit.

[26] Cf. W. Lehr, M. Sirbu, S. Gillett, op. cit.

[27] These roles are described in OECD: Developments in fibre technologies and investment, http://www.olis.oecd.org/olis/2007doc.nsf/LinkTo/NT00005E06/$FILE/JT03243516.PDF.

might reduce the existing advantage of incumbent networks.

- Whenever governments open up roads and pavements 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 coordination by operators to roll-out networks at the same time.

2. Government as Producer

The role of *producer* is defined as actually investing in new networks. This implies that the government / the public provides the financial means to build up the networks. Specific public funds to (co-) finance network rollout are tools which would follow these lines.

3. Government as Regulator

The role of *regulator* is limited to the government's role in introducing an independent telecommunications regulator trying to guarantee a competitive marketplace, i.e. the government is not the regulator itself but is responsible for creating the environment in which independent regulation can take place. Some points that will need to be taken into account are:

- *Business models* for new networks are sensitive to roll-out costs, population density and penetration rates and therefore show significant first-mover advantages and a bias toward existing networks on a local level. Recent research shows that the viability of investments in next generation networks is difficult to achieve and that later entrants face even more difficult conditions, assuming that the penetration develops moderately.[28] This first-mover advantage 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, which 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 and may be seen as one of the main reasons to move in the direction of a concept of "regionalisation", i.e. regulatory interventions which either determine sub-national markets or apply remedies on a sub-national basis.[29] This is also reflected by the OECD:[30] "The impact of penetration rates on the monthly price for an all-fibre network is such that it is unlikely there will [be] 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 viability of investments and business cases 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. As the OECD explains:[31] "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 the 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, the British regulator, has addressed the issue of regulation for next generation access networks and sees its challenge as removing barriers to investment in NGA whilst maintaining effective competition. In its 2007 consultation, OFCOM proposed two parallel options for competition in NGA:[32]

- passive competition, where operators are required to open up parts of their physical infrastructure; for

[28] Cf. WIK-Consult: The Economics of Next Generation Access - Final Report, September 2008.

[29] Cf. M. Ehrler, E. Ruhle, G. Berger: Regionalisierung der TK-Regulierung: Mehr oder weniger Wettbewerb?, in: Computer und Recht, No. 11, 2008, pp. 703.

[30] Cf. OECD: Developments in fibre technologies ... , op. cit.

[31] Ibid.

[32] See postnote 305 (April 2008) by Parlamentary Office of Science and Technology, UK.

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;

- 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, and applying the "old" tools to a new technology does not always work. However, differences also exist compared with the background and regulatory policies of the past. In countries where policy aims at facilities-based competition without any sharing of networks, the different topologies chosen to develop fibre networks may not create any need to change 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 speed 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.

Conclusions

We derive the following conclusions:

- State-of-the-art telecommunications infrastructure will involve 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 market mechanism in telecommunications markets might not be sufficient to achieve this state-of-the-art infrastructure. From an economic point of view, an evolved last mile which no longer constitutes a technical bottleneck will still represent an economic bottleneck. This is backed up by the fact that all successful models mentioned above contain funding concepts which also involve other stakeholders such as developers or state/municipal government.
- The move from monopoly to competition and technological acceleration has implied a large degree of uncertainty which may lead to a sub-optimal amount of infrastructure investment.
- Alternative funding models of this kind can involve private or public investment. The OECD mentions the possible roles of the government[33] which would have an impact on "production" besides its role as stimulator and regulator.
- The EU commission's approach to next generation access displays an attempt to regulate technical and commercial aspects of access to NGA in a very detailed manner across Europe. This not only pre-determines the policies by national regulators but also impacts the incentives to invest – at least for incumbent operators. On the other hand – many issues are addressed but not resolved by the draft recommendation which means that regulatory uncertainty is not lowered. A first assessment on how this recommendation – if it were implemented unchanged – would affect existing business models of ANOs can be given nevertheless.
- Non-facilities based competition needs to be based on an open access policy.
- Full infrastructure competition in fibre networks may not be realised 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 the situation with respect to investment in next generation networks in telecommunications in the light of the regulatory environment as it exists for the time being seems to indicate that competition and investment represent some kind of dichotomy. This means that a balance needs to be struck between these two conflicting goals. The regulatory approach is a key factor here to create the right level of investment.

[33] Cf. OECD: Developments in fibre technologies ... , op. cit., p. 36.