Next Generation Networks in Europe

Broadband in 2011 and beyond

LIBERTYGLOBAL
POLICY SERIES

Arthur D Little

Next Generation Networks in Europe

Broadband in 2011 and beyond

Arthur D Little

Main Conclusions

1. Next Generation Networks (NGNs) are very high bandwidth networks featuring an architecture built for further growth, seamlessly integrating mobility, quad-play and high-end services.
2. Following years of commoditization and ARPU decline, Next Generation Networks will allow new opportunities for growth in the broadband market.
3. By 2010-2012, many European countries (even the latecomers), will have reached an 80-90% broadband household penetration rate. Further revenue growth potential will mainly come from subscription add-ons, averaging 30% in Western Europe up to 2011.
4. The battle for the consumer will be fought not over access, but over content and services. Multiple-play will evolve in terms of quality, availability, convergence and mobility; it will be the main driver of higher bandwidth requirements until 2011.
5. Growth is expected in innovative broadband services, high-end video services (HD, DVR and VOD) and fixed-to-mobile convergence. Apart from traditional infrastructure- and service providers, new, over-the-top market entrants (Google, Yahoo, MSN, Apple/iPod, etc.) are expected to benefit from this growth.
6. Competition between converged operators and new players will be intense, and so will be cooperation. The market is set to consolidate and converge.
7. Three infrastructure architectures are set to become Next Generation Networks in Europe. These are VDSL, Cable and FTTH. The roadmaps for upgrading access technology to the main broadband infrastructures have already been drawn up and now show the way to next generation broadband. Different wireless extensions will be essential, hence creating "NGN clusters" around each of these infrastructures.
8. How quickly these infrastructure architectures reach "Next Generation Network" status will depend not mainly on their speed or bandwidth – as market demand for bandwidth until 2011 and beyond are accommodated by these networks –, but more importantly on their ability to integrate the service offering, to build scale and to develop the "anytime, anywhere-concept".
9. All networks are equally well positioned to compete, so there are no clear winners here, however:
   a. VDSL is expected to dominate because of its superior scale.
   b. Cable will excel in next-generation video services such as HD-based services and applications.
   c. FTTH will mostly be relevant at a local/regional level, assuming it is able to offer more than superior bandwidth.

10. Existing broadband infrastructures will be compelled to migrate towards NGNs as they need to constantly upgrade their networks. They will need to:
    a. Seize opportunities to provide fixed-to-mobile convergence, scale, bandwidth and QoS management
    b. Meet challenges in providing full triple- and quad-play bundles, and face intense competition from over-the-top providers (Google, Yahoo, MSN, Apple/iPod etc.).
11. Next generation Broadband policies should be aimed at maximizing growth opportunities in the market. As network elements, access platforms and services become more modular and generic, new revenue streams become available. This is confirmed by the trend towards stabilizing Broadband ARPU after years of decline and commoditization
12. Government-sponsored metropolitan FTTH networks in already competitive broadband areas could harm competition. The current drivers for such sponsorship are political rather than economic. By far the majority of these initiatives lack the scale and level of network integration needed to become true national competitors. For these networks to become viable, incumbent operators would need to either partner with them or buy them. Depending on the regulatory and competitive situation, incumbent operators could as a third option build their own FTTH infrastructure.
13. Migration to NGNs however is a precondition for growth. Before infrastructure operators can be expected to commit to invest in NGNs on a large scale, however, they first need a certain amount of reassurance that public policies will preserve their value proposition
14. Any future NGN policy in Europe will need to find a balance between allowing some form of deregulation to stimulate investments whilst preserving the results of its legacy approach and sustain the level of infrastructure competition that was created by the existing regulatory framework.

Executive Summary

What does the future hold for Broadband? As part of the Liberty Global Policy series, Arthur D. Little has been asked to carry out an objective review of current developments in what is generically called "The Next Generation Broadband Market". The results of this study should be of interest to all key market players, as they struggle to make sense of Broadband developments in the short- and mid-term, anticipate the role of regulatory authorities, and decide on what their next moves should be.

The market continues to grow and offers opportunities for new market entrants

Broadband is becoming the dominant access mode to the internet. By 2010-2012, several countries (even the latecomers) will reach an 80-90% household penetration rate. Further revenue growth potential will mainly come from subscription add-ons, averaging 30% in Western Europe up to 2011.

The growth in Broadband subscribers over the last several years has been impressive and is expected to continue to show double-digit growth in most important global markets. Based on Arthur D. Little's proprietary Broadband market model, we estimate the global Broadband market to be worth USD 75 bn in total revenues in 2006. Total Broadband revenues are expected to exceed USD 145 bn by 2010, increasingly attracting players from different industries, trying to capture a piece of this pie.

Broadband also provides attractive opportunities for new market entrants trying to leverage the growing Broadband customer base of currently approximately 200 million households worldwide. For individual/mobile Broadband use, the customer base will in some markets exceed the number of households due to the high penetration of embedded mobile/wireless devices with Broadband capability. New market players are making their entry with innovative business models that challenge established players and force them to start rethinking their strategies.

The battle for the consumer will be fought over content and services, not access

Different competitive patterns will drive Broadband growth in different markets with the Netherlands, Switzerland and France, being the fastest growing markets within Europe. In matured countries, the basis of competition will shift from price and bandwidth to converged services and content. Average telecom revenues per capita, currently EUR 50/month in Europe including fixed and mobile voice and data services, are expected to grow by only 0.8% per year up to 2010, of which an annual 2% for content and services in 2006. Broadband ARPU continues to decline (at least in Europe), whereas the decline in access ARPU is levelling off in Asia. A similar levelling off is expected in Europe around 2008-2009.

Multiple-play, which will evolve in terms of quality, availability, convergence and mobility, is going to be the main driver of higher bandwidth requirements until 2011. The term "Broadband" will cover a wide range of service levels in terms of bandwidth from 1Mbit/s to 100Mbit/s. However, we believe that the highest bandwidth offerings will exceed the requirements of users and the capacity of service suppliers to fill them with

content and services in the mid-term. Bandwidth demand by next generation services and applications will not increase exponentially despite the current bandwidth hype. The main drivers of future bandwidth demand are video services on the entertainment side, as well as video-capable search-based services on the information and transactional side. As the majority of Broadband customers are still experiencing bandwidths below 1Mbit/s, the migration to higher bandwidth is not expected to take place in the immediate future. It will become visible in a couple of years. Most markets, including Switzerland, France and Austria, will have highest demands in the 1-6Mbit/s range in 2011. Still, 30-50% of Broadband households will have 6-30Mbit/s in 2011; not more than 10% of Broadband households are expected to exceed 30Mbit/s in 2011. An analysis of up- and download bandwidth requirements of next generation Broadband services suggests that 8Mbit/s upload and 50Mbit/s download rate will be sufficient by 2011 and can be adequately served by HFC or DSL networks.

The next generation in Broadband services is characterized by the availability of increasingly IP-based-Broadband access services, across converged, multimode access platforms (fixed and mobile). Service bundling will influence revenue growth, but will be needed above all to reduce churn. Seamlessly integrated multiple-play is becoming a key competitive factor. Multiple-play will include an increasingly high-quality bundled telephony (including video telephony), personalized audio/video services (high-definition television, broadcasting, IP-TV, video/audio on demand services, PVR, EPG, etc.) and high-speed internet access. The customer is expected to require ever-increasing flexibility to create his own bundle anytime and anywhere.

New Value-Added Services such as location ("follow-me-") based services, personalization services, pervasive computing/file sharing and others will continue to evolve and are expected to be primarily driven by so-called internet players / "Web 2.0" companies. However, none of these services are expected to have become "mainstream" by 2012. The role of these new players is probably the greatest uncertainty in the future of Broadband, becoming effective at first in the USA and later also in Europe. They could seriously challenge the business models of the traditional network operators. It is evident for example that Google is building up its own network resources in the USA to accompany its enormous computing assets and to secure a strong negotiating position with respect to network operators. Google wants to ensure the fast possible speeds for its content on the internet. Network operators on the other hand consider new traffic management techniques to ensure Quality of Service for both end-customers and content operators. Could such a scenario develop in Europe as well?

It must be remembered that telephone companies still depend for most of their revenues and profits upon narrowband services (voice, SMS) which are irrelevant to these new players as a direct source of revenues for them. If the new players offer these narrowband services on a large scale as complements to their offering and supporting features for their services and applications, they could wreak enormous damage on today's major network operators. A key issue for the operators therefore is whether to try to develop creative mutually beneficial ways of collaborating with the new players or to fight them directly on their own battleground, which has enormous implications for the culture and capabilities they will have to build internally.

The situation in Europe for cable operators is somewhat more heterogeneous than it is for telecom operators, since their strengths, weaknesses, regulatory environments, his-

tory and other key influences on their competitiveness vary widely from one country to another.

Converged operators and new players will compete intensely but will also be forced to cooperate. The market is set to consolidate and converge

The industry has talked a lot about the advent of convergence and converging media for some years. Today, we see that convergence is starting to play an important role in future market developments. Convergence will take place both in terms of services and access networks, as the consumer will increasingly require ubiquitous and uninterrupted services. Convenience is thereby going to be a very important retention factor.

Convergence will result in intensified competition and inevitably in "converged" consolidation in the sector. As a result, prices will continue to be under pressure and margins will initially decline, but as the industry further matures, stabilization can be expected.

Existing infrastructure operators must focus on providing seamless integrated access, while being alert to the strategies and tactics of innovative players outside the industry. Each infrastructure operator will face choices of either trying to partner with successful „outsiders" or reorient their own businesses and build the capabilities to participate in new sources of online revenues themselves, while fending off the invaders through combinations of regulatory manoeuvres, sales and marketing initiatives and bandwidth management techniques.

The vision of Broadband for the year 2011 will depend on anticipated changes in the competitive environment. Arthur D. Little believes that the market will converge and consolidate. In this context, we have developed three distinct scenarios to illustrate the different directions the industry might take:

- "Evolution towards integration" (operators are dominant)
- "Shift of value" (content/services providers and web-based players are dominant)
- "Sponsored environment" (government/utility assets compete with liberalized market)

As yet, it is not clear, which scenario with which business model will ultimately prevail and the fight for the consumer's "share of wallet" is likely to be intense between operators and new service providers. In particular, it remains to be seen to what extent there is a real danger of total disintermediation of operators, though this does not seem to be a fully realistic scenario in the mid-term. The scenarios will vary from one operator to another, depending on the quality of their individual strategic decisions and their success in execution. Neither telephone companies nor cable operators are pre-destined to encounter a common fate.

A sponsored environment scenario with government/utility assets is unlikely and lacks of an economic rationale on a European scale. Furthermore, such a scenario may ultimately slow down market development by causing margins to deteriorate for the main players, instead of creating a level playing field.

"Converged" operators are in our view likely to lead the competitive landscape in 2012, with many of today's major incumbents offering broader portfolios of services and

expanding their geographic coverage. There is ample evidence to support this hypothesis. On the one hand, fixed operators seek to complement their offerings with mobile services, while mobile-only operators on the other hand try to secure access to fixed high-speed Broadband. Moreover, several content providers are creating MVNO business models to build platforms to potentially distribute their content.

New outside internet players, such as Google, Yahoo, eBay, Apple/iPod and Microsoft will not only apply the necessary pressure on DSL incumbents to accelerate the development of their next generation Broadband services. They will also become relevant partners in shaping the future of the Broadband landscape.

On the other hand, operators will seek to offer proprietary content to their customers, with the objective to maximize client retention. Operators may also opt to open up their networks to selected third-party service providers in order to enhance their overall service to their customer base.

Convergence and consolidation should theoretically create opportunities to achieve synergies in marketing, procurement of equipment and content, R&D, operations, as well as in back office related functions. Whether or not such synergies can be reaped will depend on management commitment at the highest levels of the companies involved. The players likely to belong to this group include France Telecom, British Telecom, Deutsche Telekom, Vodafone, Telefonica and potentially Liberty Global. Other important players (Telenor, Telecom Italia, KPN, Swisscom, Telekom Austria, etc.) are likely either to be taken over or to create strong partnerships.

New Generation Networks being rolled-out in the next few years will accommodate the projected growth, but no single access technology is set to dominate

When we talk of New Generation Networks, we refer to the *gradual evolution from traditional circuit-switched and broadcast networks (for voice and video respectively) to internet protocol-based full service packet networks.*

The term "Next Generation Network" (NGN) is normally associated with a telecom incumbents' future network. However, Arthur D. Little believes that the NGN concept should be further extended to cover not only telecom incumbents, but also *all* relevant competing Broadband (infrastructure) operators regarding:

- What will constitute a next generation network for each operator from a technology (upgrade) perspective and what are the corresponding investments.
- *Reasons for deciding* to invest in a Next Generation Network from the perspective of responding to key *business strategy* drivers relative to each infrastructure (cable, telecom, FTTH, wireless) in anticipation of the future development of the Broadband market
- *A promising timing and entry-point*

The Arthur D. Little concept is based on the assumption that there is no single, universal definition of a NGN. A NGN is however interpreted differently for every competing current – and future – Broadband infrastructure operator. Reflecting differences in technology roadmaps and strategic business objectives, there will be various competing NGNs of different technologies and different unique selling propositions (USPs). We

believe that same kind of services will be delivered on three competing platforms (DSL, HFC and FTTH) for ultra high-performance Broadband with only minimal differences in features and characteristics. User perception on the different competing products will be marginal. However, the cost of deploying network upgrades from an operators' perspective differs a lot, mainly with regard to scalability. However, there are signs that planned infrastructure upgrades into FTTH, VDSL2 (20-100Mbit/s downstream) and EuroDOCSIS 3.0 (up to 400Mbit/s downstream with channel bonding) could overshoot bandwidth requirements at least until 2011. The concept of NGNs is therefore multi-dimensional, not one-dimensional or exclusively technology-driven.

A few key points need to be made here with respect to next generation Broadband networks:

- Next generation Broadband networks will support mobility and will allow seamless provision of services to user.
- Isolated Broadband networks will therefore gradually evolve into multiple, connected and ubiquitously available next generation Broadband networks.
- However, operators must be selective and cautious with respect to the timing of upgrading access networks or extending transmission capacity and content servers.

The shift to NGN will enable new services to be delivered over the internet. As such it will allow customers to make separate choices between the provision of services and the provision of connectivity. This in turn will allow for more freedom and flexibility for customers to choose various offerings from different service providers and create their own "dynamic bundles". This possible disintermediation is certain to ultimately put additional downward pressure on prices, forcing operators to reflect seriously upon their future business models, as well as to add innovative features to their networks (such as dynamic provisioning, guaranteed QoS, etc.).

Gradual commoditization of Broadband access heralds a new era of a converged telecom industry, signalling unprecedented industry transformation not witnessed before. The term "Broadband" in next generation networks will cover a wide range of service levels in terms of bandwidth from 1Mbit/s to 100Mbit/s.

However, we believe that the highest bandwidth offerings will exceed the requirements of the vast majority of users and service suppliers are not likely to be able to fill this capacity with content and services in the mid term.

We currently do not see a single technology as being *universally* superior to others in providing future Broadband products and services. The competitive advantage of one technology versus another depends on the *usage scenarios*; HFC has strengths in high bandwidth broadcasting services with add-on interactive IP services, whereas the xDSL technology is stronger in Europe (though not in USA or India) when positioned as a basic IP access infrastructure supporting on-demand services. Cable operators should pay serious attention to converged services and need to think carefully about developing a mobile strategy if they have not already done so. Due to capacity limitations, wireless access networks do not directly compete with fixed next generation Broadband networks but mobile-enabled fixed next generation networks will have a competitive advantage over stand-alone fixed networks. Although investments in FTTX (at least FTTC) roll-out are ultimately inevitable for major operators in coming 3-4 years, there will be no

clear technical or financial business case for quite some years to come. An interesting question is raised by the Web 2.0 phenomenon, one characteristic of which is a growing role for user-generated content. If this trend continues, demand will grow among consumers for symmetric rather than asymmetric Broadband transport, which predominates today with ADSL- and cable modem-based services.

Public policy needs to stimulate market-led transition to NGNs

Debates on regulating Next Generation Networks (NGNs) are approaching center stage in 2006 as the European Regulators Group is to adopt a report on NGN regulatory principles this year. For all market players, anticipating regulatory developments remains an essential part of their competitive strategy of going forward.

From a pure consumer perspective, there are some basic features that users want, such as competition, full interoperability, open platforms and flexibility in creating their own bundles. There are also features that users seek to avoid, such as so-called "walled gardens", bottlenecks and being locked into particular technologies or to specific operators.

Regulation is the logical step to move from monopoly to competition. As soon as regulated markets start to grow, the competitive intensity will increase. At this stage the regulator can move towards deregulation. This step has only been taken to a significant extent in some few mature markets, such as the US, Singapore and Hong Kong. Deregulation is also a viable instrument for securing long term consumer interests in many European markets.

We are currently seeing regulatory authorities across the EU to be experimenting with various approaches.

We believe that any regulatory approach should be embedded in a sound policy based on a thorough understanding of the dynamics of the next generation Broadband market as described above and should designed to maximize its overall growth.

Before infrastructure operators can be expected to commit to invest in NGNs on a large scale, they first need a certain amount of reassurance that public policies will preserve the value proposition inherent in the vertically integrated network operator model. This implies that they would not consider entering into any retail or wholesale obligations if they thought these could lead to disintermediation and a disproportionate shift of value to infrastructure-independent services providers operating over the application layer. A balance could be found by stimulating commercial arrangements such as QoS deals between infrastructure providers and over-the-top providers to offer innovative Broadband products in the form of attractive new customer tiers.

The basic premise of deregulation seems to be the best way forward to accelerate investments in NGNs in Europe. The ladder concept, which underlies the implementation of a sophisticated regime of regulated forms of competition, does not appear to be working well in most European Broadband markets. Secondly, the basic assumption underlying the USA' laisser-faire approach, namely that market forces and technology change will act to counter the market power of dominant players over time, also seems set to become reality in Europe, looking at the pace of IP deployment and the changing face of competition on the next generation Broadband market. However, as noted the situation differs

significantly from one European country to another. In particular, this is, because the strength of competition between cable operators and telephone companies in different countries varies from insignificant to substantial. Regulators may have to intervene more strongly to stimulate competition in areas with no significant Broadband facility competition from cable operators and emphasize for instance the need for adequate spectrum and attractive conditions for investment in Broadband wireless.

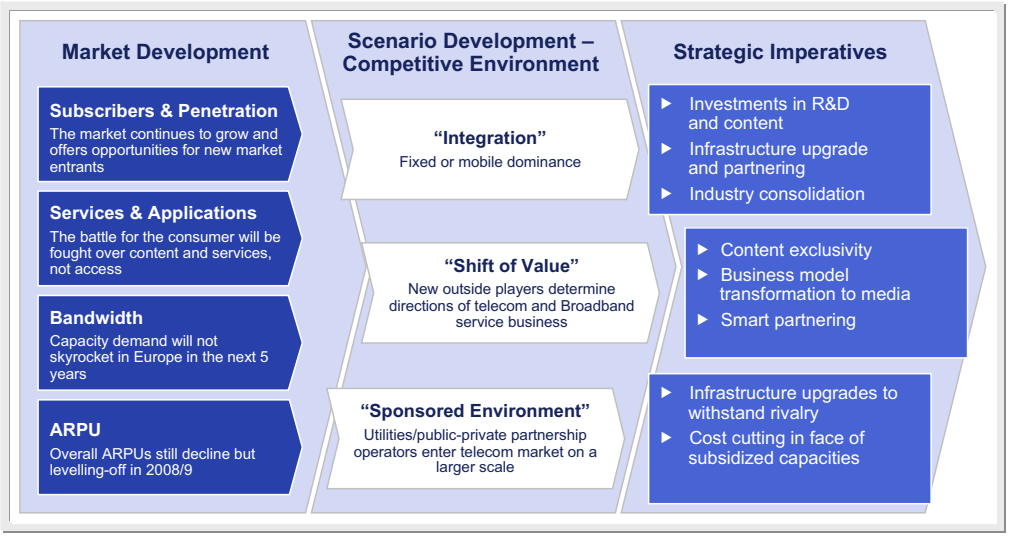
Expected outcome of the current review of the regulatory framework – Overall in Europe the regulatory framework has long been unfavorable to investment in the local access network. As stated later in this report, several markets show an insufficient penetration of competing local Broadband infrastructures. Ofcom has come under criticism for putting in place a policy that verbally supports facilities-based competition, but in practice gives plenty of incentives to service based competition. The situation is similar in other EU countries. This is as significant as the migration to NGNs is also an investment problem. A regulatory framework that creates a lot of space for service based competition does not support an infrastructure investment climate. Mobile Network Operators will want to keep the status quo – a competitive market that is predictable and positive to them. Regulation in the EU will therefore remain strongly influenced by service-based competition. As a result, investment in EU telecoms is likely to continue to lag US and Asia levels. Service-based providers will survive longer in EU, and will not drive innovation in services and increased Broadband bandwidth, supported by legacy networks. Rules on interconnection between IP-based networks and PSTN networks can influence the feasibility of business models depending on the market power of each network. Fixed-to-mobile convergence will reshape the industry structure and may lead to consolidation and increased market power of integrated players and Cable TV is likely to be affected by IP TV (starting now in Hong Kong).

Based on the above, we recommend that regulators adopt the following four key premises in the migration towards Next Generation Broadband:

- Stimulate Market-led transition to NGNs
- Limit State Aid for NGNs only to cases of clear market failure
- Stimulate NGN-Infrastructure competition going forward
- Broaden the EC's approach to Market Definitions – "Think out of the box"

Part 1 Vision of the Next Generation Broadband Market

What new direction is the Broadband market likely to take? In Part 1 of this report, we sketch our vision of the next generation Broadband market. This vision is based on current market developments and inspired by a wide range of industry scenarios, which together highlight the challenges that each Broadband infrastructure will have to meet in order to stay competitive.



Subscribers and Penetration – Broadband is becoming the most significant access mode to the internet. By 2010-2012, a few countries (even the latecomers) with an 80-90% penetration rate of households via fixed or wireless platforms will be able to call Broadband access a ubiquitous service. Further growth potential will come from additional subscriber; another 30% percentage points of households (so called "penetration adds") can be expected in all benchmarked western and northern European countries, with Norway (32% penetration adds), Germany (32%), and the UK (31%) growing above average. The current technology split in terms of Broadband customers is likely to remain at existing levels, with limited influence from FTTH and mobile Broadband. As for FTTH, interviews with industry players support our estimates of < 5% FTTH Broadband deployment, more commonly in greenfield areas with favorable economics than brownfield areas. An exception is Norway with an estimated FTTH penetration of 13% in 2011. As for Broadband, we expect a maximum of 10% substitution by mobile in countries with large mobile Broadband roll-outs and fixed bandwidths below 10Mbit/s. Otherwise, mobile will serve as a complementary network. All mobile phones will have high-band-width capability.

Services and Applications – The next generation in future Broadband services is characterized by the availability of Broadband access services across converged, multimode access platforms (fixed and mobile), as well as by the potential for radical innovations in revenue-generating business models. Video services will play a major role in accelerating the multimedia trend across all infrastructures. "Getting it right the first time" is imperative; IPTV and other future service providers must avoid quality and technological issues, as these could result in a major setback for all telecom operators in their drive to com-

pete with traditional video program providers such as cable TV companies. In Taiwan, for example, lack of attractive content significantly lowered Chunghwa's projected subscriber base. Existing infrastructure operators must focus on providing seamless integrated access while remaining alert to the strategies and tactics of innovative players outside the industry. In doing so, infrastructure operators will have to decide whether to partner with successful "outsiders", or alternatively to reorient their own businesses and build the capabilities to participate in new sources of online revenues themselves while fending off the invaders through combinations of regulatory manoeuvres, marketing initiatives and bandwidth management techniques. Most innovation in video services is expected from application layer service providers, such as Google, Yahoo, Apple/iPod and Microsoft, leveraging their internet experience. Follow-me services and self-generated content could potentially require radically increased upstream capability as stored content (downloaded, PVR-saved) is streamed to wherever the customer has a Broadband connection. Rapid development in this direction could create great uncertainty and disruption in the telecom industry, even though it is not yet clear whether such services will take off on a large scale before 2011.

Bandwidth – The term "Broadband" in Next Generation Networks will cover a wide range of service levels in terms of bandwidth from 1Mbit/s to 100Mbit/s. However, we believe that the highest band-width offerings will exceed the requirements of users and service suppliers to fill them with content and services in the mid-term. Despite the current bandwidth hype, we do not expect Bandwidth demand by next generation services and applications to increase exponentially. The main drivers of future band-width demand are video services on the entertainment side and video-capable, search-based services on the information and transactional side. As the majority of Broadband customers are still experiencing bandwidths below 1Mbit/s, the migration to higher bandwidth is not expected to take place in the immediate future. It will become visible in a couple of years. The Netherlands is expected to lead in customer demand for bandwidth with slightly more than 50% asking for 6-30Mbit/s in 2011. Most other markets will see highest demand in the 1-6Mbit/s range, including Switzerland, France and Austria. Still, 30-50% of Broadband households will have 6-30Mbit/s in 2011, while not more than 10% of Broadband households expected to exceed 30Mbit/s. An analysis of up- and download bandwidth requirements of next generation Broadband services suggests that 8Mbit/s upload and 50Mbit/s download rate will be sufficient by 2011 and can be served by HFC and DSL networks.

ARPU – Broadband ARPU in Europe continues to decline, whereas this decline is levelling off in Asia. The pre-eminent drivers for ARPU growth will not be access, but cross-selling and convergent offers. New revenue streams for infrastructure operators will be found in bundling Broadband connectivity with added-value services/IP-based services and in commercial QoS agreements with application layer service providers, leading to new consumer segmentation possibilities (on-demand Broadband). These new services represent the main opportunity to avoid further commoditization of the Broadband market. Cable operators may be able to drive ARPU figures a bit higher for Pay-TV services, but this is not likely to drive the average ARPU above Euro 55-75, with the possible exception of a minority of high-spend users. What is certain is that the battle for ARPU share will increase, depending on the potential industry scenario (convergence vs. shift of value), services and content made available by different players.

The fast pace of development in the telecom environment may result in significant changes within the value chain by 2011. On both the infrastructure and service sides, players from in- and outside the industry are ready to capture market shares from established Broadband leaders (namely incumbents and cable operators). Broadband operators therefore cannot afford any delays in upgrading the infrastructure or rolling out converged services. Inactivity is not an option!

Scenario Development — Competitive Environment

Developing the right vision of Broadband in the year 2011 depends strongly on changes in the competitive environment. Driven by this uncertainty, we have developed four distinct scenarios to better illustrate our appraisement of the future. Whereas telecoms operators are in the driver's seat in scenario A1, there are certainly more drivers and cars in scenarios A2, while telecom industry is potentially becoming a passenger without any special privileges in scenario B and C:

- **Scenario A1 – Evolution towards Integration (Fixed Dominance)**
  Fixed operators "own the customer" by offering fully convergent communication and entertainment solutions.
- **Scenario A2 – Evolution towards Integration (Mobile Dominance)**
  Pure mobile operators enter the Broadband market on a massive scale and continue to cannibalise market value, leading to a mobile-dominated, but still convergent telecom environment.
- **Scenario B – Shift of Value**
  The telecom industry as we know it is subsumed within a larger playing field and new outside players (Google, Yahoo, eBay, Apple/iPod, Microsoft, Nintendo, etc.) determine the directions of the telecom and Broadband service business.
- **Scenario C – Sponsored Environment**
  Utilities and public-private-partnership operators enter the telecom market on a large scale, rolling out extensive communication networks that are often subsidized by cities and local governments to compete with existing traditional Broadband infrastructures in a liberalized market.

The scenarios above produce different combinations of winners and losers in the Broadband-dominated environment. Their diverse characteristics have correspondingly diverse implications for market participants as they endeavour to identify and exploit strategic gaps and influence the outcome of the scenario in their favour. We regard "Convergence" (scenario A) as the most likely, followed by "Shift of Value" (scenario B) and the "Sponsored Environment" (scenario C).

Scenario A1 – Evolution towards Integration (Fixed Dominance): In this scenario, fixed operators "own the customer" by offering fully convergent communication and entertainment solutions. This scenario is driven by large players, who have the financial and operational capacity to offer all-in-one solutions (incumbents, cable operators). The main motivation for these actors is to grow through adding value from other markets (e.g. mobile telecoms, television for incumbents and telephony for cable operators) to their traditional business. Other players may react to this scenario either by entering into "smart partnerships" with the dominant players (e.g. content producers), by adopting a niche focus (e.g. no-frills mobile players) or even by withdrawing from the mar-

ket (e.g. small fixed operators who have failed to position themselves in the convergence arena and sell their major assets, their customers, to a large consolidating player).

Scenario A2 – Evolution towards Integration (Mobile Dominance): In this scenario, pure mobile operators enter the fixed Broadband market on a massive scale and continue to cannibalize market value, leading to a mobile-dominated, but still convergent telecom environment. This scenario is driven by today's pure mobile operators who have the financial and operational power to enter the fixed segment on a massive scale. The first move of these players is typically to expand their services on fixed infrastructure platforms (e.g. DSL, HFC) to provide higher throughputs. The main motivation for them is to grow through cannibalizing value from other markets (e.g. fixed telecoms, television). Other players may react to this scenario either by entering into "smart partnerships" with the dominant players (e.g. content producers), by adopting a niche focus (e.g. pure fixed players) or even withdraw from the market (for instance small mobile operators with a inappropriate strategic alignment and who become target object for an acquisition by a competitor).

Scenario B – Shift of Value: In this scenario, a new generation of players dominates the market; there is no traditional ownership of consumers because the sources of revenues are fragmented. The scenario is driven by new service-oriented players and content providers (e.g. Google, Yahoo, Apple/iPod and Microsoft) who leverage their current assets by appropriating the telecom value chain for themselves as simply one element within the overall portfolio of services and capabilities they offer to their customers. These new players use existing operators as "access pipes" to reach the customer or even build up efficient infrastructure (e.g. Google in the USA through the WiFi City Project in San Francisco). Access becomes a commodity, whereas content and services are the key differentiators as well as motivators of customers' choices and behavior. DSL incumbents no longer sit in the driver's seat but become passengers (with no or little scope for backseat driving), as illustrated in the case studies from the USA featuring Vonage, Novus and Shaw Communications. The main motivation for these new players is revenue growth through cannibalizing value from traditional Broadband operators and more importantly creating new markets for content and innovative business models that rely upon non-bandwidth sources of revenue, such as advertising and percentages of the value of person-to-person transactions. This scenario will result in a massive consolidation of network operators, leading to a significant reduction in their number, as well as to substantial reductions in the margins the survivors can hope to sustain.

Scenario C – Sponsored Environment: In this scenario, utilities and public private partnerships (PPPs) enter the telecoms market by rolling out extensive communication networks that are often subsidized by cities and local governments. They expand their footprints, focusing on integrated triple play services and the access step of the Broadband value chain. These operators use FTTH last mile networks to access the customer. The scenario is driven by many different stakeholders (utilities, cities, housing corporations, private investors and fibre technology vendors). The corresponding motivations differ significantly. Utilities focus on revenue growth through cannibalizing value from telecoms. Private investors watch ROI carefully, whereas housing corporations intend to increase the property value of their estates. Local governments and cities show a politically driven motivation of boosting local economies by pushing their regions or cities to prominent positions in terms of the capacity and coverage of fibre networks, and in terms of Broadband access options for SMEs, residents, tourists, and (public) institutions.

This scenario is rated as the least likely because of the key role that direct government intervention will have to play to make it widespread and further the lack of experience which such ventures have in competing in risky markets. It is doubtful whether sponsored FTTH networks will be economically sustainable beyond pilot phases. Nevertheless, in the early phase of roll-out of NGNs by traditional infrastructure providers, which is likely to be focused on big metropolitan areas first, competition from local, sponsored city fibre networks could have a significant impact on the competitive environment.

The most likely situations in which Scenario C may become significant in the longer term some limited geographies is where these fibre networks fill a gap which commercial network operators are slow to fill and the networks are made available on a competitive, timely and economically attractive basis to services and applications providers.

Next Generation Broadband Market Development

What *challenges* will each Broadband infrastructure have to meet to stay competitive? In this chapter, we sketch the main characteristics of next generation Broadband market of the future:

- Development of services/applications and the corresponding requirements for bandwidth and interactivity
- ARPU developments for each type of service and connectivity
- Market entry of new, converged Broadband platforms, as well as application layer service providers, increasing the risk of disintermediation for network operators
- Changing consumer demand and requirements reflecting convergence of access platforms (instead of speed alone as the most prominent aspect of competing sales pitches, customer demand moves to QoS, bundling of connectivity and services, seamless service provision and ubiquity of access generally).

1.1 Subscribers and Penetration

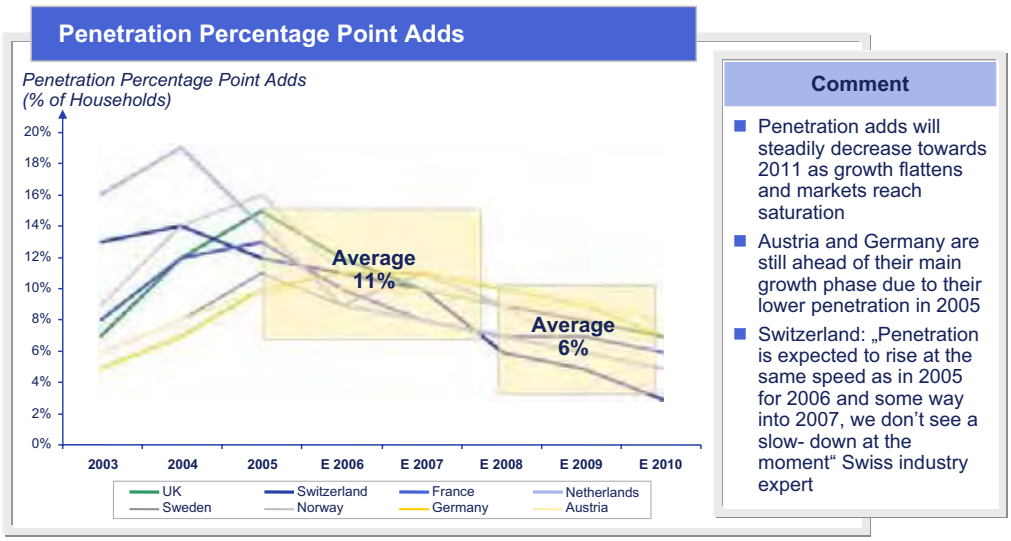
Full throttle – Broadband growth engine running at top speed

Current Penetration Growth – The Netherlands, Norway, Switzerland and France are the most dynamic markets in terms of Broadband growth, showing significant gains in penetration. During 2005, these countries added between 13 and 16 penetration percentage points, similar to the gains experienced the year before. Similar to most other European markets, penetration added in the first nine months of 2005 exceeded the first nine months of 2004.

Future Penetration Growth – No radical downturn in Broadband growth has yet appeared in Europe, although the market is expected to mature in the years to come. Several factors continue to drive this surprising positive growth, including substantial price declines, higher available bandwidth, greater marketing endeavours, special offers and extended service innovation. The total Broadband market in Western Europe is forecast to grow at 11% penetration points added annually until 2008 and then at 6% penetration points added until 2011.

Future Penetration Rates – We expect countries such as Switzerland, Sweden and Norway to reach a household penetration of more than 90% by 2011, while the Netherlands is likely to outperform all other European markets, reaching almost 100% by that time. These remarkably high penetration rates will be enabled by three key markets trends:

- First, the growing number of personal computers, especially laptops;
- Second, the occurrence of Broadband-enabled set-top boxes to be used for IPTV;
- Third, the continuing demand from smaller business customers purchasing residential Broadband packages.

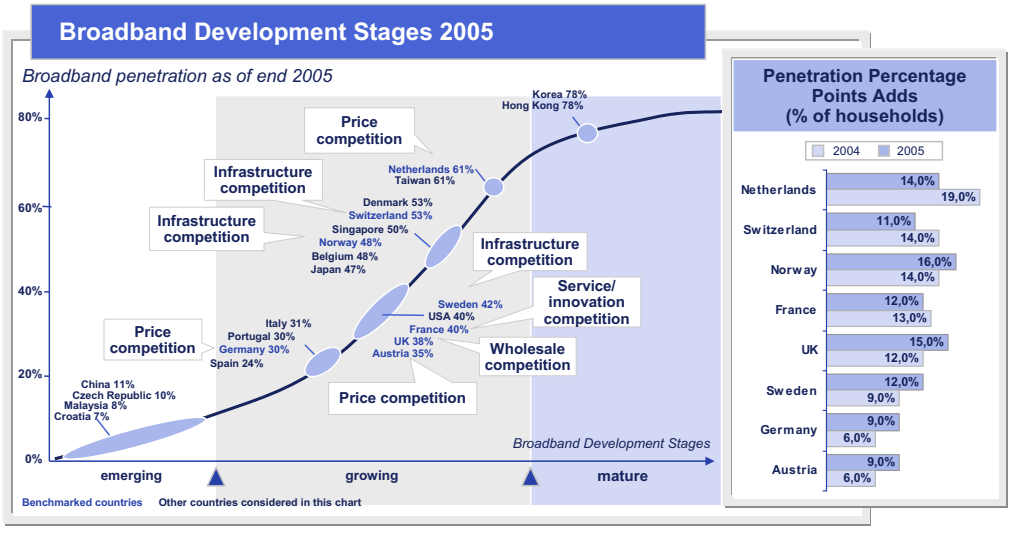


Source: Proprietary Arthur D. Little Broadband Research

"We think that the commonly stated 50% penetration for 2008 in Western Europe is underestimated."

(Quote from interview with operators, regulators, content providers and equipment manufacturers)

Broadband Subscriber Base – In terms of subscriber base, Germany, the UK and France are the indisputable giants within the European Broadband market. By the end of 2005, Germany, Europe's biggest Broadband market, accounted for more than 11 million subscriptions alone.



Source: Proprietary Arthur D. Little Broadband Research

Penetration Growth Drivers – Western European countries show different competitive patterns, ranging from infrastructure competition to price competition to service innovation competition. Interviews with industry experts show that each market is driven by one dominant pattern, while others are not necessarily absent but are of minor importance. Broadband competition in the Netherlands, for example, focuses on end-user price, while service offerings in France are already highly influenced by the demand for service innovations such as converged services and IPTV. As Broadband markets mature in the long term, we expect a general trend towards service innovation, which will pro-

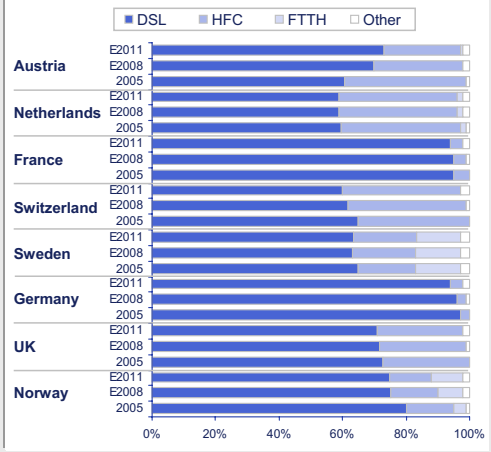
vide the customer similar digital TV service experiences over HFC, DSL Broadband and maybe FTTH.

> *"Competition is shifting from price competition (to allow basic connectivity) to service induced bandwidth competition in later years. The ultimate key factor determining the Broadband access competitive game will be service and content availability, not the infrastructure capabilities."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

Technology revolution not in sight

Overall changes in technology split – No rapid change in the split of access technologies is likely for European Broadband markets in the coming years. DSL and HFC operators have positioned themselves as Broadband leaders, carving out their territories with significant marketing efforts that have created unique brands and customer recognition. Nevertheless, incumbents have significantly less market power in Broadband than in many other telecom segments. An incumbent operator typically has a line market share in the narrowband market of over 85% and owns the customer relationship of these lines, whereas in the Broadband market, average retail market share is 46%, according to our estimates in 2005. As the majority of Broadband customers are still experiencing bandwidths below 1Mbit/s, the migration to higher bandwidth is not expected to take place in the immediate future. It will become visible in a couple of years. Most markets including Switzerland, France and Austria will have highest demands in the 1-6Mbit/s range in 2011. Still, 30-50% of Broadband households will have 6-30Mbit/s in 2011; not more than 10% of Broadband households are expected to exceed 30Mbit/s in 2011. Requirements of next generation Broadband services can be served by HFC and DSL networks.

Share of Technology (as % of Subscribers)



Comment

- Germany and France will be dominated by more than 80% DSL subscribers and HFC share will remain below 15%
- Sweden will have the highest FTTH share with 13% in 2011
- Norway is expected to take up 10% FTTH share mostly at the expense of DSL
- Switzerland retains the same market share for HFC
- Other technologies include satellite and fixed wireless access
- Switzerland: *„We expect penetration to grow to 80% to 90% on long terms. Of course we regularly discuss footprint expansion although the gap to the incumbent will always remain"* Swiss industry expert
- Austria: *"Mobile may take up to a third in 2011 but FTTH will only play a minor role. HFC may reach 20% and DSL around 40%"* Austrian industry expert
- Austria has seen strong DSL growth in 2005 and will further increase its DSL as growth is mainly coming from rural and thus DSL dominated regions

Source: Proprietary Arthur D. Little Broadband Research

DSL vs. HFC – In general, we expect DSL to remain the dominant access technology in terms of subscribers with more than a 60% share of technologies in 2011. The share of HFC is likely to remain stable in most countries. We do not expect a significant shift from DSL to HFC even in countries with underdeveloped cable footprints, such as Germany.

Impact of FTTH – Based on current developments and expert interviews, we do not expect FTTH to reach a significant share in most countries. Unfavorable economics and foreseeable operational issues of locally focused roll-outs are the main rationale behind this expectation. However, there will be exceptions. Because Nordic utilities managed to acquire up to 200,000 FTTH subscriptions in 2005, we expect this alternative model to succeed (at least in some countries), leading to a 13% share in 2011 in Norway, for example. For Sweden, we forecast an FTTH share of roughly 5%.

1.2 Services and Application

Triple Play – from hype to mainstream. Evolution lies in availability of convergent access platforms and new market entrants

Evolution of Triple Play – Broadband services today are defined by the edges of the triple play triangle; Broadband internet access, telephony and digital television. The triple play has moved beyond the realm of hype to become a mainstream force affecting all types of service providers.

> *"Our basic product was a bundle of Broadband and TV. Then we launched voice and now 90% of gross adds will have telephony as well."*
> *(Quote from interview with a cable operators)*

In the coming years, triple play will be an important driver of higher bandwidth requirements and will evolve in terms of quality, availability, convergence and mobility. A new, converged service generation will enable a significant shift in the current balance in the telecoms market; a provider of corresponding services may be able to offer higher customer value while simultaneously competing with different existing players. This will affect the everyday life of subscribers as information and entertainment become available anywhere and anytime

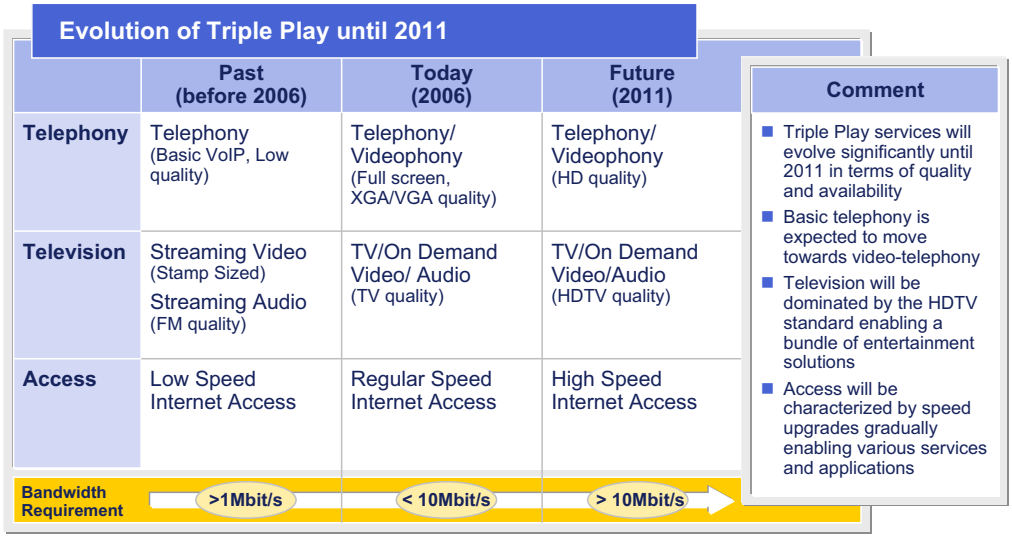
Future development of telephony – Basic telephony is expected to become a commodity as discount pricing is already the key driver behind Voice over IP. Highly discounted VoIP bundles, which are now widely available across Europe, are becoming an increasing threat for traditional voice-focused operators because they cannibalise existing market value.

> *"Voice will gradually tend towards a zero-marginal revenue and the only way to compete is on value-added services such as IPTV."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

Future development of television – Television in 2011 will be dominated by the HDTV standard, enabling a multitude of entertainment solutions. HDTV channels will be offered both by cable operators and telecom players, as during the Soccer World Championships 2006.

> *"HDTV should not arrive on large scale before end of 2007"*
> *(Quote from interview with Broadband operators)*

Future development of access – Pure access will remain a key product for operators as many customers will still make use of free internet content. It will be characterized by down- and upstream speed upgrades, gradually enabling various new services and applications.



Source: Arthur D. Little

Potential service providers – Future Broadband service providers will not necessarily be limited to the traditional players known today. Currently, the Broadband market is divided between fixed and mobile operators, either incumbents or non-incumbents. In the future, we will see four groups of players offering convergent services over the telecommunications infrastructure:

- fixed-line DSL and cable operators (e.g. France Telecom, UPC)
- mobile operators (e.g. Vodafone, T-mobile)
- internet/content players (e.g. Yahoo, Google, Apple/iPod, Microsoft, Warner Bros.)
- manufacturers (e.g. Nokia, Cisco, Apple)

Current market evidence – Fixed and mobile operators are already expanding their footprints to be better positioned to offer convergent services, while internet/content players are increasingly securing available key content through partnerships. An example of a manufacturer entering the telecommunications value chain is Nintendo, who is beginning to connect gaming devices through WiFi technology. Next, more off-line devices will be connected to the mobile internet. Certainly, one of the most prominent examples is Apple with its iPod series and mobile phone plans.

New generation applications will enrich user experience

Video-based applications and user-generated content become important drivers – On top of triple play services, a variety of applications using Broadband technology will enrich the user experience by 2011. These applications may either be offered by traditional Broadband operators or by a new generation of players. Examples of these applications include instant messaging (IM)/collaboration services, content sharing platforms, and interactive gaming. On top of these services, a variety of applications using Broad-

band will enrich the user experience by 2011; these applications can be clustered into the categories “communication”, “information”, and “lifestyle”.

Web 2.0 – The term,‘Web 2.0“ is currently used with little differentiation. Web 2.0 is a concept with no hard boundaries but principles that tie together a set of ideas which in general are decentralized. The internet is seen as an application platform rather than a document delivery system. Sharing, participating openness, flexibility and decentralization are the primary underlying principles. From a social perspective, Web 2.0 is a change of paradigm which reflects changes within today‘s society towards greater freedom of expression, individualism and self-exposure.

Web 1.0 was a time when people believed that a software company (e.g. Netscape) could be a contender for leadership of the industry, whereas Web 2.0 is a time when people are recognizing that leadership in the computer industry has passed from traditional software companies to a new kind of internet service company. Nowadays, people are using the internet increasingly as a channel for open communication with a higher social character. There are many so called “Web 2.0-companies”, several of them have successfully participated in this evolution and transformed themselves (see chart below).

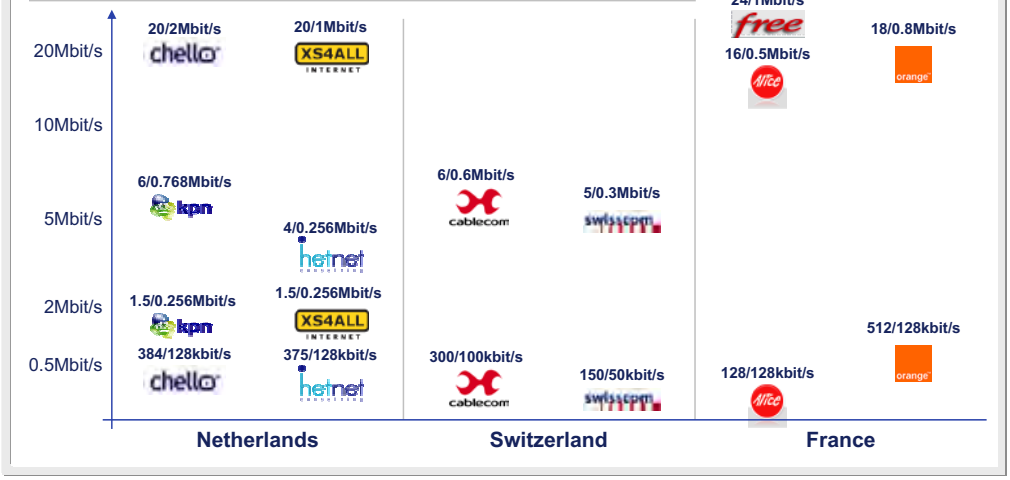
1.3 Bandwidth

Capacity demand will not skyrocket in Europe in the next 5 years, bundling + ubiquity of access will drive attractiveness of Broadband products

Current bandwidth supply – Operators have been continuously increasing bandwidth with the objective of keeping ARPU stable. In the past, available access bandwidth has always exceeded application needs. In 1995, the maximum available European bandwidth was roughly 64kbit/s; this rate increased sharply to 0.5Mbit/s in 2000 and to 1.5Mbit/s in 2002. Today, 20Mbit/s is currently the highest Broadband speed offered in benchmarked countries, while operators also focus on low-level entry products at 1Mbit/s. In addition, the marginal benefit and hence the value increase, of each subsequent speed rise is sys-

tematically decreasing. However, as the application development and speed demands of these applications do not require significant increases in currently available Broadband connectivity services, operators will need to find new ways to improve the attractiveness of their products, through bundling and ubiquity of access.

Highest and Lowest Bandwidth Offers



Source: Proprietary Arthur D. Little Broadband Analysis – August 2006

Download/Upload Bandwidth

Overall bandwidth demand – Normal browsing, emailing, messaging and peer-to-peer applications can be reasonably well served with 2-3Mbit/s of downstream capacity. This capacity can normally support several simultaneous users in a household. The access to a website does not require more than 200kbit/s and the average traffic consumption is still below 1GB per month. Furthermore, the customer's value of additional downstream bandwidth is decreasing in reverse proportion to the rise because usage differences for basic applications are no longer visible. Many subscribers who first upgraded their capacity are now downgrading again, meaning that they have changed back to lower-speed packages, to save costs. This is a trend that is occurring in many markets across Europe.

Evolution in Bandwidth Demand

Downstream			Upstream
Current and Future Capacity Drivers	Current Requirement	Future Requirement	Future Requirement
Browsing & Emailing	0.2-1Mbit/s	0.2-5Mbit/s	2Mbit/s
HDTV	n/a	8-10Mbit/s	0.5Mbit/s
Personal Content/P2P Filesharing	0.2-1Mbit/s	0.2-5Mbit/s	2Mbit/s
VoIP	< 1Mbit/s	< 1Mbit/s	< 0.5Mbit/s
Interactive Gaming	0.2-1Mbit/s	2Mbit/s	3Mbit/s
Instant Messaging	< 1Mbit/s	< 1Mbit/s	< 1Mbit/s
Audio, Webradio, Podcast	< 0,5Mbit/s	< 0,5Mbit/s	< 0,5Mbit/s
Video Conferencing	0.2-1Mbit/s	2Mbit/s	3Mbit/s
Home Monitoring	0.2-1Mbit/s	2Mbit/s	0.5Mbit/s
E-Tax/Government/Etc.	n/a**	< 5Mbit/s	< 0.5Mbit/s
Average demand per household	**3- 8Mbit/s***	**< 50Mbit/s**	**< 8Mbit/s**

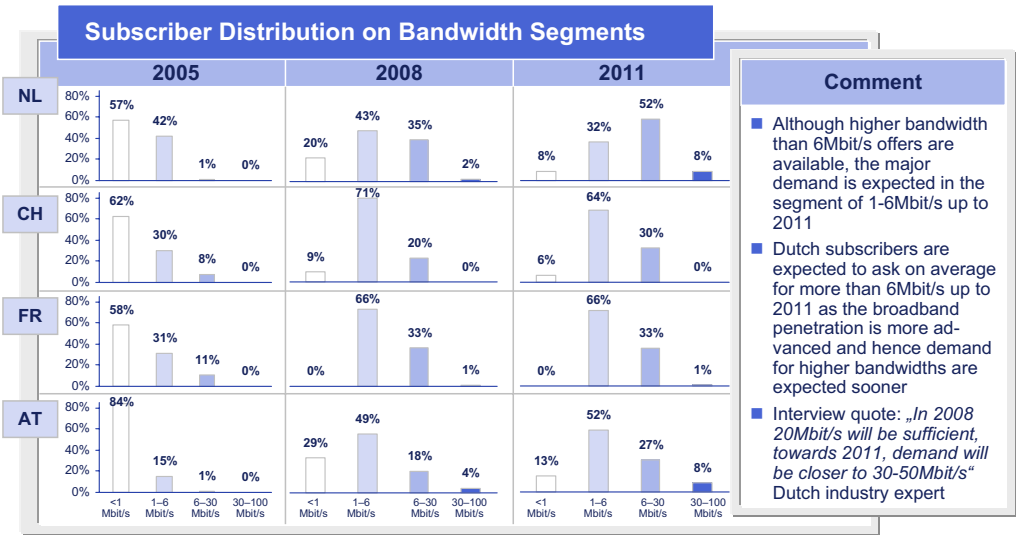
Comment

- HDTV will primarily drive capacity. One channel will require 8-10Mbit/s with MPEG4. A high-usage household simultaneously receiving 3 channels would not require more than 30Mbit/s for HDTV
- Today's upload speed is accounting for roughly 15% of the download
- Assuming 50Mbit/s average download in 2011, this would lead to roughly 8Mbit/s upload (supply)
- When looking at future upstream demand, it appears reasonable that this can be well delivered by DSL and HFC networks

Source: Ericsson, Alcatel, Arthur D. Little; *) According to current standard offers KPN (3Mbit/s) and UPC (8Mbit/s) **) Today: Mainly Browsing

Bandwidth drivers – Broadband capacity will be predominantly driven by TV and video services. One HDTV channel would require 8-10Mbit/s, using the MPEG 4 compression technique, which would result in 30-50Mbit/s with 4 channels and Broadband internet in high bandwidth households. Other non-video applications need less downstream capacity. Requirements of small-sized businesses will be similar to households, while the special needs of large accounts will be served by business service operators as is already the case. Follow-me services, where data stored on devices located at home, is made available to the user's mobile device, will require radically more upstream capacity as stored content (self-generated, downloaded, PVR-saved) will be streamed to wherever the customer has a Broadband connection.

Future bandwidth development – Interviews with industry experts indicate that the majority of the subscriber base in most countries will remain in the range of up to 6Mbit/s in 2008. This may hold true until 2011. Nevertheless, packages with significantly higher capacities will be available for heavy users. We expect differences in the demand between countries as well. Dutch subscribers, for instance, are expected to ask for more than 6Mbit/s in 2011. Because their Broadband penetration is more advanced, demand for higher bandwidths is expected sooner.



Source: Proprietary Arthur D. Little Broadband Analysis

> *"In 2008, 20Mbit/s will be sufficient in the Netherlands. However towards 2011, demand will be closer to 30-50Mbit/s."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

Future bandwidth supply – Future bandwidth requirements seem to be easily fulfilled with planned infrastructure upgrades and network optimization measures. Market experts clearly indicate that available bandwidth will outstrip any foreseen application in the future, similar to the development in the past.

> *"Most customers will be in the 1-6Mbit segment in 2008 as well as in 2011, but the share of 6-30Mbit/s subscribers will increase."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

1.4 ARPU

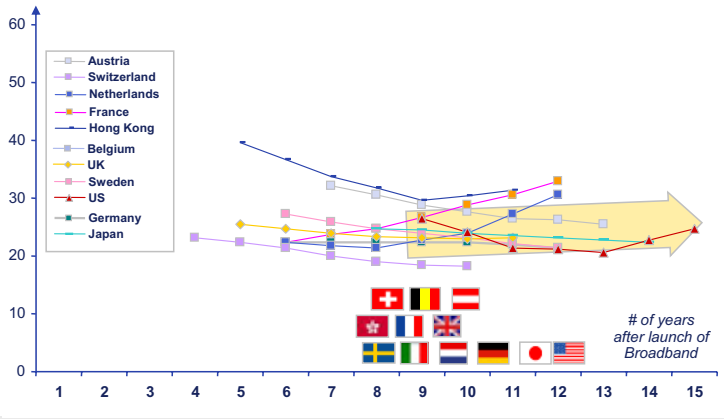
Light at the end of the ARPU tunnel?

Previous trends in development of Broadband ARPU – Looking at pure Broadband ARPU, we have seen a declining trend in recent years throughout Europe. Broadband access ARPU has decreased with market penetration growth, reflecting the price sensitivity of basic access in the mass market. Consequently, access ARPU is typically highest in embryonic markets.

Broadband ARPU drivers – Broadband ARPU has been highly impacted by declining prices in Europe. Development in retail pricing varies substantially by country, but the trend of declining prices continues. Countries with the strongest declines in price in 2005 were Germany (32%), the UK (25%), the Netherlands (15%) and Spain (12%). As prices fall, consumers are typically getting more for less. Bandwidth is increasing significantly in most markets, typically at no extra cost to the consumer, and unlimited fixed calling bundles are increasingly available either for a low monthly charge or within the Broadband monthly charge. In France, consumers can also get 90 "free" TV channels as part of the service. All in all, this appears to be a very good deal for the customer.

Broadband ARPU Development

Total Broadband ARPU (access, traffic, and VAS) in PPP-EUR; adjusted to countries' price levels



Comment

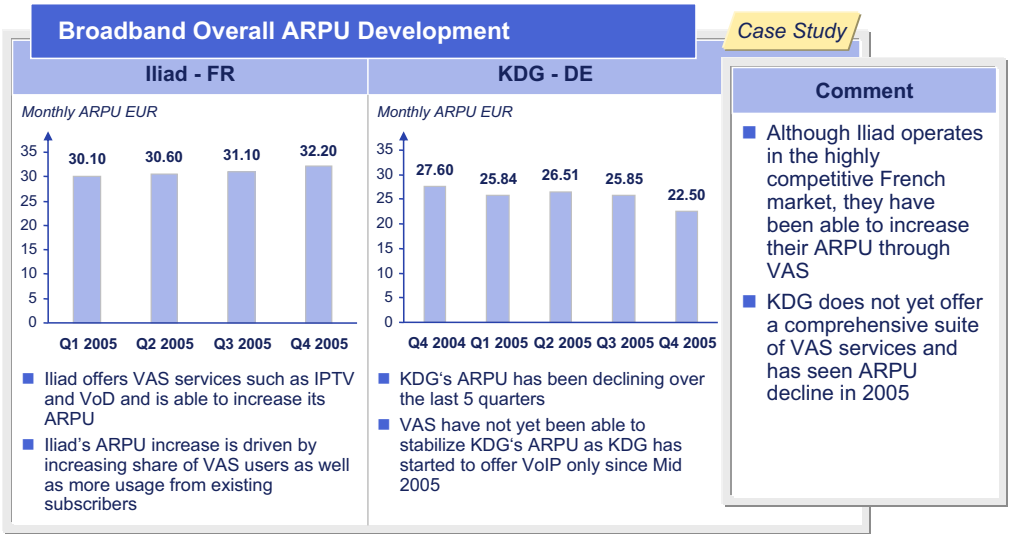
- Interviews with industry experts show that ARPU is expected to stabilize by 2008/2009 in most markets
- "We expect declining ARPU to be stabilized in 2008 by VAS services" Dutch industry expert
- „TV offers will increase ARPU but will not affect the bottom line very much, as costs for content are generally high (e.g. digital rights)" Swiss industry Expert

Source: Proprietary Arthur D. Little Broadband Research **Flags indicate position of countries** (*years after launch of Broadband, e.g. USA has launched Broadband in 1994 and is now (2006) in year 12*)

Broadband ARPU outlook – In the future, pure Broadband access ARPU will decline steadily, moving towards a range of EUR 15-25 per household, while multiple-play, service-related fixed Broadband ARPU (Broadband access, video, TV, gaming and telephony) will steadily increase, leading to an overall ARPU in the range of EUR 55-75 by 2011. This thesis is supported by most industry experts, who share a rather conservative view on Broadband ARPU.

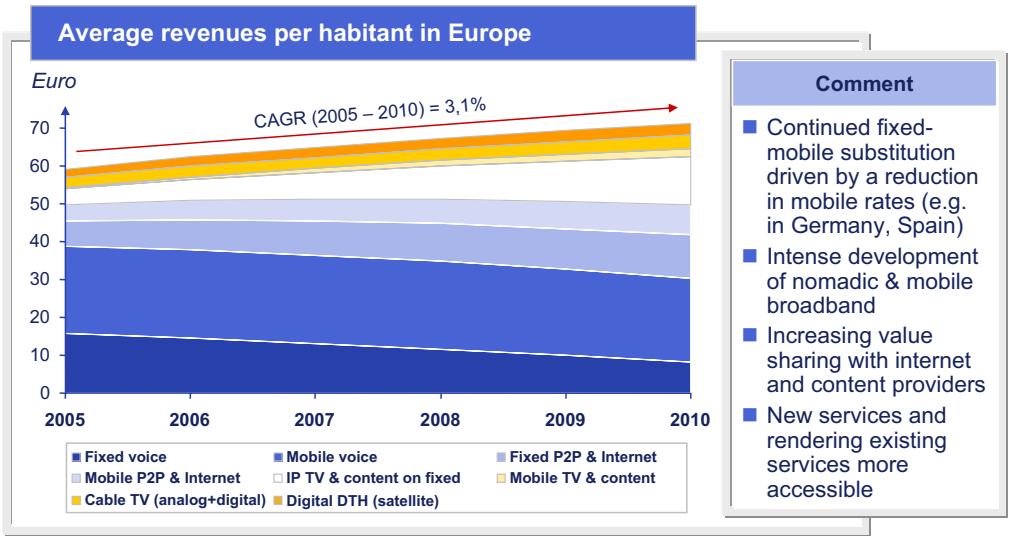
> *"There won't be a killer application, but for TV there is some upside potential for ARPU. We expect ARPU to be in a range of EUR 45 to 70 on long terms. A change in the overall downwards trend can be expected for 2008."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

Two case studies show different ARPU effects; Iliad/Free has been able to increase its ARPU through Value Added Services (VAS), while by contrast the ARPU of KDG, who didn't develop any corresponding offerings, has declined.



Source: Proprietary Arthur D. Little Broadband Analysis

Total telecom spending – Looking generally at the telecommunications market in the benchmarked countries, the total telecommunication services market (including voice, data and all other content/TV both for fixed and mobile operators) currently generates average revenues per capita of roughly EUR 50 per month. Although convergence brings new opportunities in services, the telecommunications market is expected to grow at only 3.1% per year until 2011 because traditional segments (such as fixed voice) are expected to decrease further.

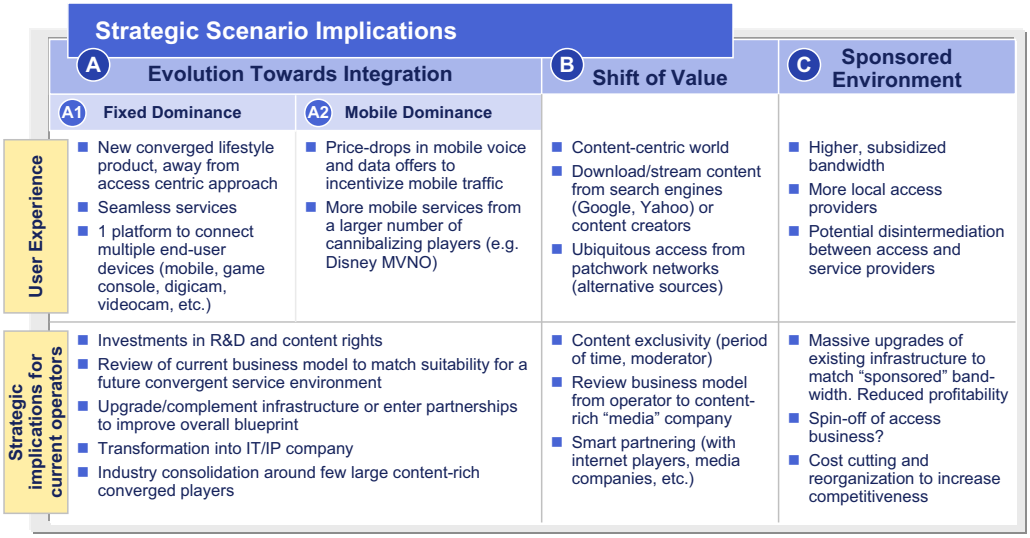


Source: Exane BNP Paribas, Arthur D. Little analysis; 2006

Competitive Landscape 2011 – Scenario Development

The telecom environment is undergoing a massive transformation (both quantitatively and structurally) as the excesses of the investment frenzy of the late 1990s fade into the past and entirely new business models attract investors. Broadband operators cannot afford delays in infrastructure upgrades and a slow roll-out of converged services. On both, the infrastructure and the service side, out-of-industry players are ready to go after market shares of existing Broadband operators.

The vision of Broadband for the year 2011 will depend on anticipated changes in the competitive environment. In the light of this incertitude, we have developed three distinct scenarios to illustrate the different directions the industry might take. Scenario planning is a structured exercise to provide a clearer picture of a future that is complex and uncertain. We have done so in order to help executives and investors better anticipate the risks, opportunities and consequences of alternative courses of action which they wish to consider:



Source: Arthur D. Little

1.5 Scenario A1: Evolution towards Integration (Fixed Dominance)

The revenge of the wireline

User experience – The user experience will be much more attractive than today's access-centric experience, enabling a completely new kind of lifestyle. Key for operators is not only offering a product bundle, but also providing seamless services. IP connectivity is addressed with one single platform, enabling multiple end-user devices. Thus, customers may access a video from a stationary television set at home and then enable a seamless switch to a mobile device when they leave the premises, while continuing to watch the video. Also, self-created photos from mobile handsets or digital cameras can be automatically uploaded to private hard disks as the person enters the premises, while the same device is informing the customer about new emails and asking which device he/

she would like to read them on at the same time. These are only a few examples of the changes in the user experience that are characterized in this scenario.

Market Impact – The scenario's impact on the overall Broadband market will be significant. In general, service offerings to the consumer clearly improve in terms of quantity, quality and price, while demand for new services and higher Broadband speeds increases. Consumers are willing to pay for the steadily increasing number of attractive digital services, adding premium and interactive packages to their basic subscriptions. Therefore, digital TV and Broadband penetration rates rise sharply, while the average price per service actually goes down. Tariffs are mainly based on bundled flat rates that are not directly linked to the individual amount of usage.

Importance of Content – Content is an important competitive factor in this scenario and will be owned (to some extent) by the dominant telecoms operators. Telecom players seem to be gaining more and more rights to key content and try to leverage it across their access platforms of fixed-line Broadband, mobile, pay-TV, etc. (see following graph for recent content deals):

Recent Content Deals – Selective Examples *Case Study*

Content deals to-date

Operator	Content type	Comment
Belgacom	Football rights on IPTV	EUR 36m for the entire 3 year broadcasting rights for the 18 clubs playing in the Belgian football league Belgacom launched IPTV over its ADSL network in June 2005
TIM	Live TV	TIM would provide television-quality broadcasts of Mediaset's three TV channels and football for five years from 2006.
Vodafone	Mobile TV	MobileTV, launched in November 2004. Vodafone MobileTV offers 15 channels on-line and 4 live channels.
Mobistar	Mobile TV	Mobistar signed a contract with Belgian Business Television to stream TV content via mobile phones.
Orange	Mobile TV	Orange offers 18 TV channels
BT	IPTV	BT is planning to offer its customers on-demand television and video over broadband from Summer 2006. According to BT, trials would start from the beginning of 2006.
BT	Mobile TV	BT is trailing a mobile product (BT Livetime) enabling broadcast mobile TV and GSM in one handset based on the Digital Audio Broadcast (DAB) standard.
Viatel	Football rights	Partnering with Chelsea provides broadband services which includes access to all Chelsea football matches.
Hutchison	Football rights	Football service including video highlights, text alerts, club news and video goal alerts, manager interviews, video previews and analysis. UEFA Champions League highlights and content from Soccer AM, Sky Sports and Football 365.
Proximus	Mobile TV	Able to access CNN, Euronews EN, Euronews FR, FashionTV, JIM, RTL-TVI, TLB, Trace TV, Vitaya and VTM since September 2005.
Vodafone	Mobile TV	Vodafone and satellite broadcaster BSkyB announced that they are to launch a 19-channel mobile television service on 8 November 2005 using Vodafone's 3G network.
Vodafone	Football rights	Three year agreement to sponsor the UEFA Champions League commencing on 1st July 2006. Vodafone can deliver video goal alerts, full time video highlights, preview packages, backed up with a comprehensive official text and services

Source: Deutsche Bank

Strategic implications – For this scenario, players need to invest in R&D and content rights to challenge their current business model in terms of suitability for a future convergent environment. Networks and infrastructure in general need to be adapted to new customer needs. The increasing variety of services characterized by this scenario cannot be fulfilled on a single traditional platform. Therefore, the ability to leverage fixed-to-mobile solutions offering seamless access to content becomes a strategic asset in competition; bidding for additional frequency spectrum and realization of capacity with effective technologies on those platforms become essential to support customer needs at home and on the move.

Evidence – There is already evidence for this scenario in today's markets, as leading incumbents are taking broad measures to build up competencies in convergence. For instance, France Telecom's "Livebox" and "LivePhone" enable users to link various personal devices seamlessly. Telecom Italia's "Home Access Point" offers wireless access to converging services at home. British Telecom's "Bluephone" provides a fully integrated voice solution that has been developed into one of the most recognized convergent ser-

vices in the market. “Bluephone” is fixed-mobile convergence appliance whereas the convergence being referred to in the rest of the section relates more to entertainment and telecom convergence. Additional evidence for such a scenario comes from the NTL-Virgin-merger, with which the fixed-line operator NTL acquired MVNO operator Virgin to enter the mobile market.

France Telecom: Full Convergence Concept — *Case Study*

The Livebox Concept*

Livephone : the First Internet Phone

- The first BB telephone with a wireless connection to the Livebox, signalling email arrivals and automatically updating one’s Wanadoo contact list
- Access to practical content without turning on one’s computer

Source: Arthur D. Little; *) France Telecom targets 12m Liveboxes to be sold by 2008

1.6 Scenario A2: Evolution towards Integration (Mobile Dominance)

Mobile finally takes it all

Differences between first and second scenario – There are clear differences between the first and second scenario; in this second scenario, mobile operators “own the customer” by offering fully convergent communication and entertainment solutions. However, they start leveraging their high-capacity networks by aggressively gaining as much

Mobile Operators expand into Fixed Broadband

Situation	Consequence	Examples
■ Pure mobile operators are in the same need to offer convergent telecom services as fixed ones ■ This need is driven by two components: Firstly customer's demand for convergence and secondly the pressure for growth from the investor's side ■ Thus pure mobile players need to define convergence service scenarios and find alternative ways to generate revenues other than from conventional wireless services	■ LLU strategies enable mobile operators to deliver converged services which would not be feasible by reselling DSL from the incumbent ■ Mobile players have two main alternatives for leaping into the LLU market: – They could either build out their own broadband capabilities from the ground and rely on their marketing – Or they could acquire existing LLU-based broadband service providers and invest further	Vodafone announced the creation of a dedicated business division focusing on converged services in April 2006 O_2 At the same time O_2 has been exploring the LLU option, with manufacturer Fujitsu confirming it has pitched to the operator mobistar Belgian carrier Mobistar has sourced DSLAMs from Alcatel and is branching into DSL by unbundling the LL already since late 2005

Source: Light Reading, Company Information, Arthur D. Little

traffic as possible (e.g. through mobile data cards). This delays fully convergent services compared to the first scenario. While the first scenario shifts market value mainly between networks, the second scenario leads to a significant cannibalization of traffic between fixed and mobile operators.

Evidence – There is already evidence for "Evolution towards Integration" in today's markets as leading mobile operators enter the fixed Broadband market, analyzing local loop unbundling options. For instance, Vodafone Group announced in April 2006 the creation of a dedicated business division focusing on converged services. At the same time, O_2 has been exploring the unbundling option, with manufacturer Fujitsu confirming it has pitched to the operator. Last but not least, since 2005 Belgian carrier Mobistar has sourced DSLAMs from Alcatel and is branching into DSL by unbundling the local loop.

Vodafone goes for fixed Broadband?

Case Study

Screenshots

Comment

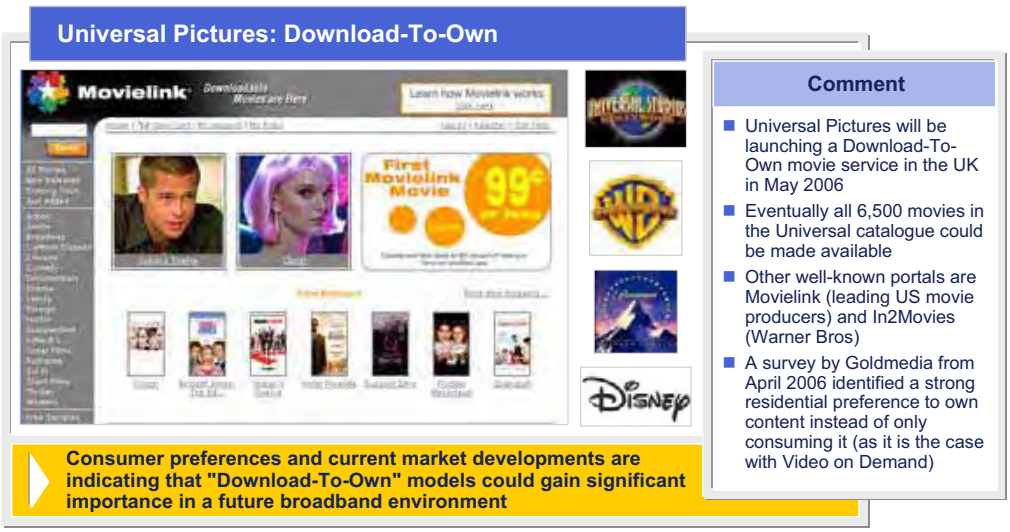
- Vodafone announced the creation of a new division called "New Businesses and Innovation" in April 2006
- This unit will focus on converged and IP services in order to deliver new revenue streams
- For analysts this means that Vodafone resell unbundled broadband services in a fixed/mobile package
- For others it suggests Vodafone may look to acquire fixed-broadband specialists to get an immediate position in the DSL market

Source: Light Reading, Company Information, Arthur D. Little

1.7 Scenario B: Shift of Value

The Googles and Yahoos to rule the world?

User experience – In the "Shift of Value" scenario, the user experience will be content-centric, while access will become a commodity with operators acting as the pipeline. The key to winning customers is to offer exclusive and extensive content (e.g. videos, music and games); relevant content rights will be held by this new generation of market participants. The market will be fragmented because it is highly unlikely that one provider will gain the rights to all content. Internet players like Google, Yahoo, Apple/iPod and Microsoft will act as content aggregators and gain some rights such as, for example, World Championship Soccer and Formula One Car Racing. Hollywood studios, like Paramount or Universal, may also distribute their blockbuster movies directly over the internet, disintermediating and bypassing the traditional aggregators.

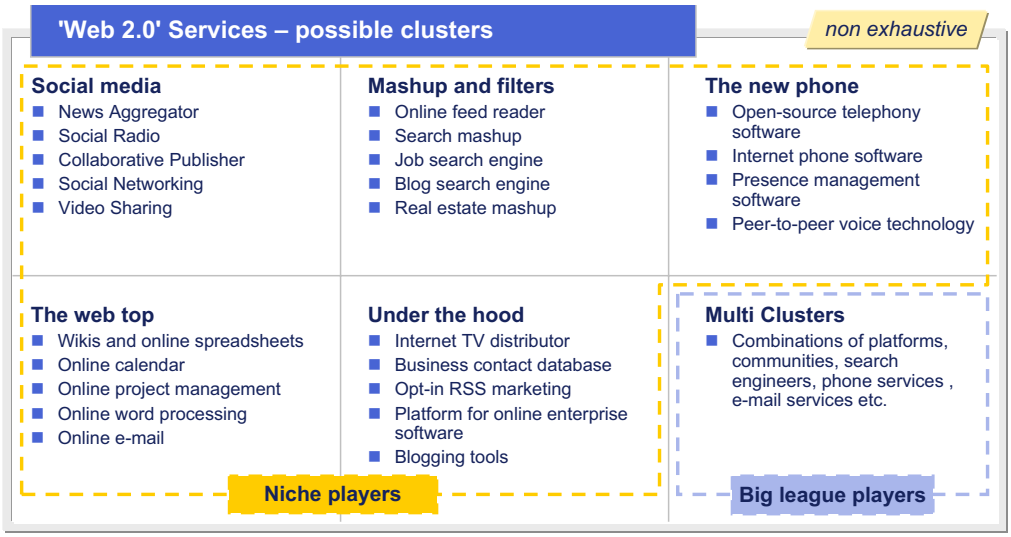


Source: Golem, CNN, Arthur D. Little

Sub Trends – Two important trends in this "world of content" would be so called on-the-go services and user generated content. "On-the-go" means subscribers can access (personal) content from anywhere in the world using common IP-based upstream services. The "Slingbox" (by Sling Media) is a already proven way to distribute live TV and recorded content from a customer's home around the world to every Broadband access point. Content sharing means that subscribers share all kinds of content (e.g. audios, videos) via dedicated applications. Today, the massive introduction of Peer2Peer video sharing is a key evolutionary step in sharing services and has significant market potential. Both key trends will result in higher relevance for the upstream channel.

Google – One intriguing observation is that Google (and other internet players as well) may disrupt the telecom sector. This would not be because they are deliberately taking aim at DSL incumbents, but because they have reasons both aggressive (increasing their role in the minds and behavior of customers) and defensive (concerns about DSL incumbents' intentions to disfavor traffic that is critical to their core services) to involve themselves directly in the provision of telecom services. For Google, telecom services would be just another application on the Net, more a complement or enabler with which to extend or enrich their core services than a major source of additional revenues. So quasi-inadvertently, they will disrupt the revenue streams and undermine the margins of DSL incumbents.

Web 2.0 – The term, "Web 2.0" has already been introduced earlier on in this report. In Web 2.0, the internet is seen as an application platform rather than a document delivery system. Sharing, participative openness, flexibility and decentralization are the primary underlying principles. From a social perspective, Web 2.0 is a change of paradigm which reflects the changes within today's society; freedom, individualism, self-exposure and so on. Web 2.0 is a changing recognition and a usage of the internet into the direction of open communication with higher social character. It is important to understand the trend Web 2.0 as it adds many new elements to the dimension of self-generated content, the importance of upstream bandwidth capability and ubiquitous access. To get a clearer picture of the actual positioning of Web 2.0 services and players, we have defined six clusters:



1. Social Media: The new culture on the Web is all about consumers creating content. It is evidenced by the nearly 30 million blogs and the 70 million photos available on Flickr.com. With a click of the mouse, anyone can be a journalist, a photographer or a DJ. The audience, that one billion-plus throng linked by the Web, is creating a new type of social media for itself. This in turn is leading to the creation of hundreds of promising Web 2.0 businesses.

2. Mashups and Filters: As we move towards Web 2.0, some of the most useful sites will be those that either help "mash up" – meaning mix and match – content from other parts of the Web or act as a "filter" for the overwhelming mountains of information now at people's fingertips. These companies use content already on the Web as a starting point and then improve it by organizing it in a new way.

3. The new Phone: For nearly a century, the phone plus voice as we know it, has existed largely in the confines of a thin copper wire. But now service providers can convert voice calls into tiny internet packets and let them loose on fast connections, thus mimicking the traditional voice experience without spending hundreds of millions on infrastructure. All that is required is powerful but cheap computers running specialized software. The Web 2.0 will be the new phone, creating fertile ground for new businesses.

4. The Webtop: Today, browser-based applications are where the action is. A killer application no longer requires hundreds of programmers slaving away on millions of lines of code. Several Web 2.0 companies have fewer than 10 engineers and can, with a little creativity, rapidly turn out popular new websites. What has changed is the way today's Web-based apps can run almost as seamlessly as programs used on the desktop with embedded audio, video and drag-and-drop ease of use.

5. Under the hood: A growing number of companies are either offering themselves as web-based platforms on which other software and businesses can be built or developing basic tools that make some of the defining hallmarks of the Web 2.0 possible.

6. Multi clusters: Multi cluster companies combine some or all of the above clusters – these companies are normally one of the big globally operating internet companies.

All trends considered under the Web 2.0 umbrella touch upon certain intelligent services with high customer added-value that have a fast growing community effect. On the one

hand, operators have the possibility to include and facilitate such services in their product portfolio or even develop and market such innovative services themselves, as means for customer lock-in and traffic generation measure. The ecosystem Web 2.0 has already created an incredible amount of content (blogs, podcasts on iTunes, videos on youtube.com, etc.) with increasing importance. As evidence, first newspapers already provide youtube videos on their content portal and such trends need to be carefully studied as they appear to decide on an appropriate partnering strategy.

Strategic implications – For the "Shift of Value" scenario, current Broadband players need either to position themselves as new generation content players or to reduce their business models to smaller access providers. The impact of this scenario on the overall Broadband market will be huge. Risk of disintermediation and the "dumb pipe" model will force current Broadband operators to open up potential new revenue streams through commercial QoS deals between network operators and over-the-top providers, resulting in more and more customer segmentation. In general, the content offerings to the consumer improve significantly in terms of quantity, quality and price. Content variety undergoes a significant increase to supply all kinds of customer entertainment demands. Individuals spend money on exclusive and premium content, while the average price for Broadband access actually goes down, becoming a commodity service. Broadband penetration rates rise sharply, while the average price per service decreases. Infrastructure in general will only play a minor role because this Broadband scenario is characterized by services, not by networks. Convergence, however, is significantly less far-reaching than in the first two scenarios. Frequency acquisition and realization of capacity with effective technologies are not the keys, in contrast to content ownership.

Evidence – Evidence for this scenario is already emerging in today's markets, as a new generation of players are enlarging their footprints in telecom. For instance, Yahoo's capability to strike exclusive deals on a global level (e.g. Yahoo's live broadcast of Howard Stern) has already brought a significant number of viewers to their small screens. Also Hollywood Studios, although reluctant to sell their blockbusters online in the past, are setting up download-to-own portals that are gaining more and more recognition (e.g. Warner Bros, Universal).

Yahoo: New Content Business

Case Study

- 6.4M live video streams on 12/16
- Set record for highest simultaneous webcast viewers (>350K)
- Millions offline brand impressions
- 580M online impressions on more than 20 Y! Properties ($2.4 M value)
- 75M PR impressions
- 12+ Y! products integrated into the Howard Nation site

- **Mission**
  - Provide the most trusted & global video experience that delivers maximum value for users, publishers and advertisers
- **Strategy**
  - Build a comprehensive and open index that enables users to find & use video, motivates publishers to share, promote, protect and monetize video and furthermore enables advertisers to reach and expand their audience
- **Objectives**
  - Become the #1 online video search experience as measured by market share, coverage, relevance and freshness

Source: Arthur D. Little

1.8 Scenario C: Sponsored Environment

In the "Sponsored Environment" scenario, FTTH deployments emerge in Europe in the shape of regional and local micro-networks, often duplicating existing Broadband infrastructure in markets where one or more fixed Broadband network operators are actively present. Two generic models exist for the exploitation of these networks:

- In the "wholesale" model, passive and active network operations and service provisioning are separated into three autonomous layers.
- In the "retail" model, the overall process mainly belongs to one single integrated operator.

In Europe, municipalities and energy utilities building FTTH are mostly deploying the wholesale model, which means that the end-to-end process is split over various stakeholders with a clear separation between access and services.

User Experience – The user experience will not change significantly, in contrast to the first three scenarios. It is not likely that the service environment will move dramatically; first of all, because there are no clear drivers in terms of service innovation (as is now the case with incumbents and cable operators) and secondly because sponsored FTTH networks do not offer converged access, but are limited to providing triple play services over a fixed connection. The benefit to the customer remains questionable. The fact that these networks are mainly regional and local makes them less attractive for service providers to provide content or develop applications at competitive prices that would really make use of the superior bandwidth potential of an end-to-end fibre connection.

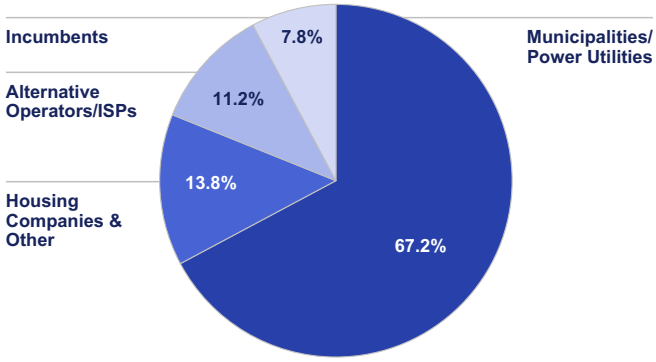
Strategic implications – In the "Sponsored Environment" scenario, existing infrastructure operators need to react with massive upgrade programmes to remain competitive as the superior bandwidth capability boosted by FTTH proponents creates the perception that the competitive edge in the next generation Broadband is centered around capacity alone. The impact on incumbents and cable operators is clearly negative as they may be forced to invest in matching capacity upgrades ahead of the (demand) curve, as well as lose out on potential revenues as customers delay subscriptions to new offered value-added services or churn to subsidized FTTH networks altogether. Existing players will potentially lose market share and will be forced to cut costs and take reorganization measures. The overall impact on revenue and profitability will depend on how widespread independent fibre deployments are. For cost reasons, these are likely to be limited to densely populated urban areas. Where competition is increasing from other infrastructure-based players (mainly cable TV networks) the incumbents are considering deploying fibre closer to their customers, which enables them to offer higher Broadband speeds using VDSL technology.

Evidence – Evidence for the Sponsored Environment scenario can already be found in today's markets as an increasing number of large cities and utilities across Europe have been preparing to set up micro fibre networks.

City governments, through public private partnerships or through their utility companies, are clearly taking the lead in building FTTH Networks in Europe. For instance, the City of Amsterdam has announced its intention to build a city-wide FTTH network ("Citynet") with 40,000 households being connected in the first roll-out phase. The City of Vienna, too, has started to roll out a municipal fibre network. Wien Strom, a utility

FTTH Initiatives from Different Kind of Players

Split



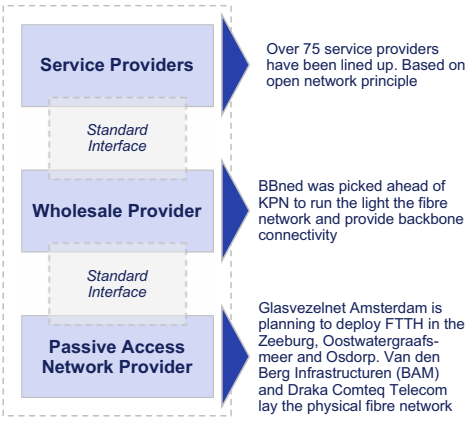
Number of Players	June 2006
Municipalities/ Power Utilities	78
Housing Companies & Other	16
Alternative Operators/ ISPs	13
Incumbents	9
Total	*116*

company owned by the city, acts as a wholesale provider by offering the fibre network to ISPs and other service providers keen to offer households triple play services. Recent press releases indicate that deployment to 50,000 homes is starting in spring 2006. By the end of the project, 950,000 households and 70,000 SMEs are to be linked up to the network (100% of households).

FTTH in Amsterdam - Netherlands

Case Study

Screenshots



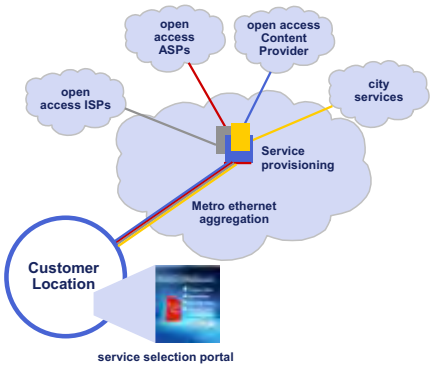
Comments

- Amsterdam City Councillors plan to roll out first phase of a citywide FTTH network in 2006 connecting 40k homes
- Construction is expected to start in 2H06 and should take 18 months to complete
- The EUR 30m cost will be funded through the City, five housing corporations and ING
- The venture will purchase capacity wholesale and operation services from BBned and use technology components from Cisco
- FTTH network is intended to expand to all of the capital's 420k homes and SMEs
- "Smart Digging" like laying cables together with utilities will be used as much as possible (neighbourhood by neighbourhood approach)
- City declares not to subsidize and to operate according to the "Market Economy Investors Principle"
- Besides Amsterdam, there are several other FTTH initiatives in the Netherlands (e.g. Rotterdam, Nuenen)

FTTH in Vienna – Austria

Case Study

Screenshots



Comments

- Vienna has been announcing FTTH plans for several years – the deployment for 50k homes will be starting before end of 2006
- 950,000 households and some 70,000 SMEs are to be linked up to the network by the end of the project (100% of households)
- Network is intended to be an open platform that ensures access for all users under equal conditions
- As WienEnergie have acquired comprehensive know-how in pilot projects, they will launch the first construction phase (50,000 households) before end of 2006 – independently of ongoing talks with other market participants
- Negotiations with substantial real estate property owners are already taking place
- Another Austrian FTTH project that is generating national attention is in the city of Ried

Despite the good intentions behind the sponsored FTTH networks, their contribution to fostering sustainable competition in the Broadband market is questionable and some case studies (e.g. Sweden and the Netherlands) show them to be economically negative.

Sweden FTTH Case Study: In view of falling fixed-line revenues and mobile penetration of close to 100% Scandinavian telecommunication service providers are forced to seek for new emerging opportunities. The industry adopted a "Triple Play" strategy to capture the growth potential in the broadband market and complemented their traditional services portfolio by a television offering. As a consequence of this impetus all operators have been building up new capacities or upgrading their networks and have tried to provide an attractive bundle of services at competitive prices by adopting new technologies that feature lower production cost per bit. In addition, further alternative infrastructure capacities are built up by cable-TV companies, local electricity distributors as well as municipal and regional development programs (e.g. Stokab). All these initiatives together lead to the situation of massive broadband over-capacities in the market, which finally results in a decrease of prices.

Analyzing the last five years of Broadband network deployment in Sweden, a great number of FTTH networks have been rolled out mainly financed by public money. These deployments were focused on smaller areas and have not had the ambition to bring nationwide coverage to all Swedish households. Only some geographic areas have been flooded with very high-speed bandwidth 20-100Mbit/s internet connections at subsidized prices. Looking at the users' bandwidth needs and type of services and applications, offered bandwidth over FTTH connections by far overshot the necessary requirements.

Such offerings lead to continuous price erosion and increasing bandwidth demand even outside these FTTH-enabled areas. Private FTTH and other Broadband operators would have needed to invest heavily into next generation Broadband networks with the outlook of continuous price erosion, which from an economic point of view is not a long-term proven business case. This is why incumbents and cable operators stopped investments. As a result of the publicly financed high-speed Broadband access at low prices, many of the FTTH operators went bankrupt and were bought by large incumbents or cable operators, e.g. Telenor bought Bredbandsbolaget (B2). After this large consolidation wave over the last 1-2 years, Sweden lacks a nationwide high-bandwidth infrastructure with patchwork FTTH deployments, an economically difficult market for further infrastructure investments.

This situation has significant strategic implications: Investment in alternative infrastructure (coaxial, fibre or copper) turn into sunk cost; from this point on, the objective for the owner is to cover its variable costs, which are marginal. The contest for a competitive triple play offering resembles a "the-winner-takes-it-all" game as the offered services will be similar and independent of the underlying technology; the winning operator/technology will take the customers' full revenue stream, while the other networks risk lacking the traffic/revenues and become obsolete. This paves the way for very fierce price competition. The described development led already to consolidation within the industry and competition is heating up:

- **TeliaSonera (dominant market player):** Telia and Sonera were forced to divest cable-TV assets as part of the regulatory requirements for the approval of their merger. Most recently TeliaSonera in Swedish media is quoted for planning to imple-

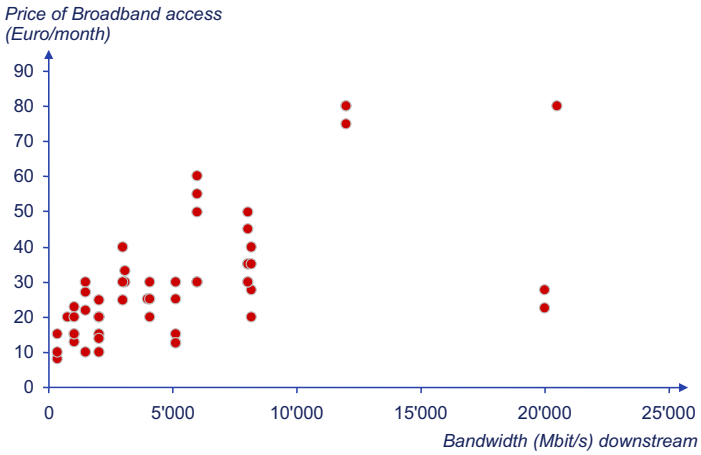
ment a fully IP based NGN network (both wireline and mobile) over the next five years.

- **ComHem (third largest player):** The cable-TV company was taken over by the private equity fund EQT, which is controlled by Investor, which, in turn, is a 40% shareholder in the 3G mobile start-up 3. ComHem was the first provider to offer triple play solutions in October 2004; since then, a triple play war has started between ComHem, Bredbandsbolaget/Bostream (the second largest player) and GlocalNet.
- **Tele2:** Suffering from a lack of access to a competitive broadband access platform, Tele2 entered in March 2005 into an agreement with Telenor to unbundle its ADSL product for 35% of Swedish households and is expected to aggressively trying to gain market share.

The economics of FTTH networks without subsidization therefore seem weak. The fact that the main independent commercial provider of triple play services over FTTH networks, namely Fastweb in Italy, stopped deploying additional fibre connections is illustrative in this regard. Fastweb is now complementing its fibre network with DSL unbundled lines, as the falling costs of unbundled local loop lines make end-to-end fibre connections uneconomic. About 35% of Fastweb's customers are currently connected via fibre to the home.

The economic outlook for the viability of sponsored FTTH networks in the long run also seems poor in view of the scale of current and future competition from existing Broadband infrastructures. In the case of the city of Amsterdam, market competition from alternative Broadband offers to residential customers is strong, as it is in the business-to-business fiber access market.

Prices vs. fixed bandwidth offerings – Amsterdam



Comment

- 6 providers offer 60 different Broadband access offerings (March 2006)
  - *4 resellers*
  - *4 network owners*
  - *2 local loop owners*
- At least 250 commercial Wireless Hotspots throughout the city providing Broadband wireless access
- 4 broadcast alternatives: UPC/Cable, Satellite, Digitenne, IPTV providers (such as Tele2), DTT providers such as KPN-TV and Scarlet TV
- At least 5 different providers of fixed business fibre connections with own networks

Source: Arthur D. Little Research, www.2surf.nl: based on 1054 EC; as of March 2006

Besides Priority Telecom (UPC) and KPN, many CLEC's have their own fibre backbones in Amsterdam, serving larger business customers directly in the Amsterdam business parks. More than 10 serious Broadband providers compete for businesses in Amsterdam. All have a network mainly running around the city's A10 ring road, connecting all major business parks. Additionally, governmental buildings like schools, universities, academic hospitals, and libraries in Amsterdam receive specific attention from operators.

Main CLEC's in Amsterdam

- More than 10 serious broadband providers compete for businesses in Amsterdam
- All have a network mainly running around the city ring (A10), connecting all major business parks

Overview of business parks and industry areas in the Amsterdam region

Source: Arthur D. Little Research

Part 2 The Concept of Next Generation Networks

The term "Next Generation Network" (NGN) is normally associated with a DSL incumbents' future network. However, Arthur D. Little believes that the NGN concept should be extended further, covering not only DSL incumbents but also all relevant Broadband (infrastructure) operators regarding:

- What will constitute a next generation network for each operator, from a technology (upgrade) perspective and what are the corresponding investments.
- *Motivations for deciding to* invest in a Next Generation Network from the perspective of responding to key business strategy drivers relative to each infrastructure (cable, telecom, FTTH, wireless) in anticipation of the future development of the Broadband market
- *A promising timing and entry-point*

The Arthur D. Little concept is based on the assumption that there is no single, universal definition of a NGN. NGN is however interpreted differently for every current – and future – Broadband infrastructure operator. Reflecting differences in technology roadmaps and strategic business objectives, there will be various competing NGNs with different technologies and different unique selling propositions (USPs). The concept of NGNs is, therefore, multi-dimensional, not one-dimensional or exclusively technology-driven.

We expect DSL and HFC technologies to continue to dominate the Broadband infrastructure market, with wireless technologies introducing mobility as an important overlay in some cases and supporting the extension of fixed services into areas where wired infrastructure is economically not viable. The role of FTTH in the next several years will be focused on largely "greenfield areas" (new buildings and housing compounds) and local/regional initiatives. However, there are signs that planned infrastructure upgrades into FTTH, VDSL2 (20-100Mbit/s downstream) and EuroDOCSIS 3.0 (up to 200Mbit/s downstream) could overshoot bandwidth requirements at least until 2011.

DSL Incumbent Strategy Drivers and Roadmap towards NGN – Operators, both incumbents and challengers, are bringing fibre closer to home, thereby overcoming the technical pitfalls of xDSL technology. ADSL2+/VDSL2 are expected to reach >50% household coverage in most countries within the next three years. Business-case-driven FTTH deployment with higher long-term ROI will play a limited role in greenfield areas and only a marginal role in "brownfield areas" (existing houses) due to unfavorable cost structures. In the backbone network, DSL incumbents will migrate step-by-step towards a packet-based next-generation network, which will be accessed over a unified IP-based xDSL access for all kinds of services. ADSL2+ in rural areas and VDSL2 in competitive urban areas will be the major access technologies, using the existing copper access infrastructure of the operators.

TV and content offerings are a means for the incumbents to fight back against the triple-play offers of cable and differentiate within the DSL market. The incumbents are increasingly looking to football rights, previously in the media domain. As the incumbents push into content, bidding for national football rights across Europe has become much more crowded. Deutsche Telekom (DT), Belgacom, Telenor, Telecom Italia and British Telecom (BT) have all made recent deals for football rights. DT has acquired the

IPTV rights to broadcast the Bundesliga for EUR 50m, compared to Arena's EUR 200m purchase of the cable rights. Telenor's Canal Digital has set up a football JV. Belgacom has taken the Belgian football rights. KPN has set up Club TV, a channel delivered over IPTV. BT has dipped its toe in with 'near live' football rights with BSkyB and PT Multimedia owns football rights in Portugal.

HFC Strategy Drivers and Roadmap towards NGN – The high transmission capabilities of coax cable network have enabled cable operators to introduce an increasing variety of telecommunication and entertainment services. Digital services (pay TV, Broadband, PPV, cable telephony, etc) are responsible for the growth of cable ARPU in the USA while the basic cable subscriber market is saturated. Operators in Asia are following the same strategy, looking for ways to increase revenue in saturated markets. Due to continuously improved technologies, the shift from analogue services such as TV and radio to new digital ones has been accelerated. Today, nearly all kinds of digital services can be provided by cable operators.

Three major measures to upgrade cable networks are available which can be deployed in parallel:

- upgrade according to future enhancements of the EuroDOCSIS standard,
- reduce segment size (number of customers served by a node)
- and reallocate bandwidth.

In Asia, the main change seems to be the move into digital services to boost revenue and lower churn, besides the change to digital TV to free up bandwidth. The high flexibility and scalability will allow cable operators to adapt their networks to customer demand and resulting product priorities. One window of opportunity will be the simpler and faster introduction of broadcast HDTV, based on the shared media access structure and the easy reallocation of bandwidth on the line. One limiting factor on cable operators' services (such as VoD and internet access) could be triggered by too many customers hav-ing to share the total available capacity on the coax access network. Another limiting factor is the regulation of the availability of analogue channels, which severely limits the efficiency of cable operators in Europe.

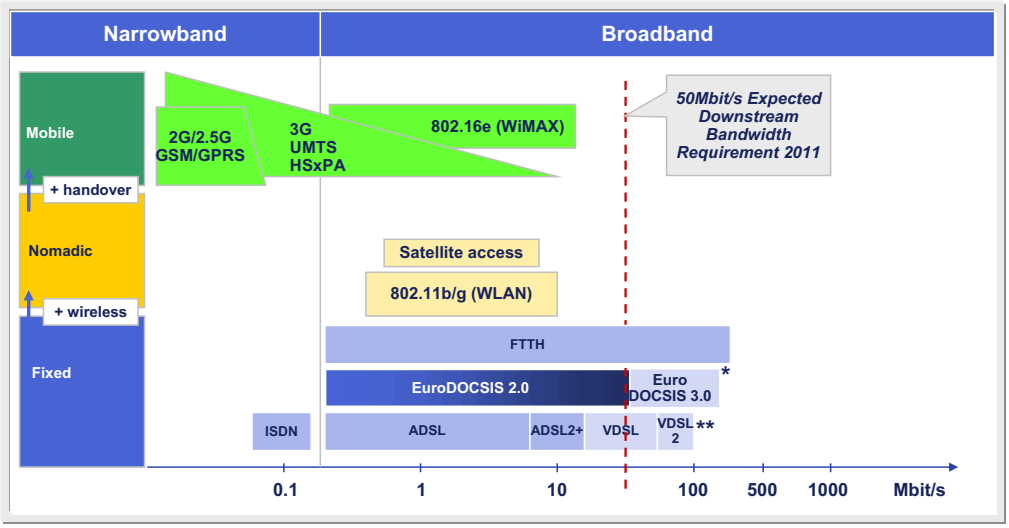
FTTH Strategy Drivers and Roadmap towards NGN – In Europe, FTTH deployment is mainly driven by utilities, cities and housing associations, where short-term ROI is not a primary concern. In Asia and USA, FTTH deployment is more often driven by commercial and public-private partnerships. However, European FTTH deployment will remain confined to local/regional geographies and will not exceed 5% of households in the benchmarked countries in 2011, except in Norway (13%). The Impact of (subsidized) FTTH deployment is highly uncertain but could drive prices down (e.g. 50% ARPU loss in Japan) and bandwidth up, leading to industry consolidation as already observed in Sweden and in Japan. In general, FTTH will provide overcapacity in the next few years because there will be no services requiring these high bandwidth needs. In the long term, however, the importance of fibre to the home will increase continuously but there will be no service need for FTTH.

Wireless Strategy Drivers and Roadmap towards NGN – Wireless is an inherent overlay to fixed Broadband networks and can add the necessary mobility element in bandwidth-hungry areas. Wireless networks will probably cannibalize fixed-line Broadband only in certain geographic areas and will allow its extension to otherwise uneco-

nomical geographies in others. Three competing mobile standards will accelerate technical upgrade dynamics:

- The UMTS family standard will develop via HSPA to Long Term Evolution (LTE) standard as of 2009/10 and will support data ranges up to 100Mbit/s.
- The CDMA EVDO standard will evolve in phases through further revisions to peak data rates from 70Mbit/s to 200Mbit/s in 2009/2010 (Rev. C/Phase 2).
- WiMax will develop to full mobility with 50Mbit/s and above (802.16e standard).

All three competing mobile standards will support theoretical bandwidths of 70-200 Mbit/s by 2011. However, the practical throughput for individual customers will stay below 10Mbit/s due to technical handset limitations and capacity sharing. In addition to the mobile wireless standards mentioned above, WiFi and meshed networks in particular have gained much in popularity over the past few years. In Taipei, WiFi penetration has reached 50%. In Hong Kong and Singapore, governments are investing in city-wide wireless networks. Similarly the USA has an increasing number of WiFi-cities, particularly as meshed networks.



*) future EuroDOCSIS 3.0: max 200Mbit/s downstream, 100Mbit/s upstream; **) future VDSL2: max 100Mbit/s downstream and 100Mbit/s upstream;
Source: Arthur D. Little Analysis, UPC, KPN

Business motivations for shift to NGNs

What motivates key players to decide (when) to move towards/invest in a Next Generation Network? In this section we anticipate how the future Broadband market is likely to develop by analyzing how players will respond to the key business strategy drivers relative to each infrastructure (DSL incumbent, HFC, FTTH, and wireless).

2.1 DSL Incumbent Strategy Drivers

Telecom Network Development towards NGN – DSL incumbents possess several legacy networks for different kinds of offered services (voice TDM network; data networks such as ATM, SDH, DWDM, FR, and X.25; IP networks; etc.), which have high

operational costs and limited flexibility for introducing new kinds of services. Because packet-based networks are more flexible and now offer possibilities to implement QoS (e.g. with the MPLS standard) and the correspondent replacement of obsolete networks has already started. This development is summarized under the title "Next Generation Networks" (NGN).

Unified packet-based networks will bring down operational costs by reducing network elements and enabling flexible implementation of new service platforms, which will also serve mobile services and will be the next step towards Fix-Mobile-Convergence (FMC). To bring these services to the customer, IP Broadband access with xDSL will gain more importance in the future.

In the Access Network, DSL Incumbents Will Focus on Using Existing Assets – DSL incumbents will focus on upgrading the existing copper infrastructure to build up future-proof Broadband access networks (min. ADSL, max. VDSL2 with FTTN/C). One reason is the pressure from investors to produce free cash flow (focus on shorter return on investments) and another reason is that these upgrades are more than adequate for serving next generation services (such as IPTV). Some DSL incumbents, like KPN, Bell, Telenor and BT will choose FTTH for greenfield areas but will follow the evolutionary path in brownfield areas. A few DSL incumbents, like Deutsche Telekom, will aggressively invest in upgrading their access network (planned budget EUR 3 bn) via FTTN+VDSL2 in the coming years.

2.2 HFC Strategy Drivers

From TV to Telecommunication and Entertainment Networks – The high transmission capabilities of coax networks have enabled cable operators to incrementally introduce a growing number of telecommunication and entertainment services. This began with the overlay of bidirectional digital signals to streamed analogue TV, enabling new services such as Broadband internet and voice. Because technology has continued to improve, the shift from analogue services (such as TV and radio) to new digital ones has been accelerated; today, nearly all kinds of digital services can be provided by cable operators, where one limiting factor could be triggered by too many customers having to share the total available capacity of the coax access network. The biggest limiting factor of all seems to be the regulatory obligation to offer analogue TV, without which sufficient bandwidth would already be available. A competitive advantage enjoyed by cable operators in the USA and Asia is that telecom incumbents' DSL local loop lengths are longer than in Europe, which negatively impacts its main competitors' broadband speed performance. One new advantage of cable is the ability to introduce HDTV in one shot to a broad customer base due to easy capacity reallocation on the cable network.

Further Utilization of the High Potential of the Coax Cable – HFC operators have a strong evolutionary path for their access network, where several measures will lead to a significant expansion in Broadband capacity. These measures increase and optimize the available capacity on the last mile of coax line and increase the fibre density to the fibre nodes (FTTN), where the coax cables are connected. An increase in fibre nodes automatically leads to increased bandwidth because this enables the segment sizes to be split and the number of customers per cable segment on the shared coax access line to be reduced.

2.3 FTTH Strategy Drivers

Roll-out of Fibre Access Infrastructure – Fibre infrastructure may grow in importance in the long term, while in the medium term it is partly deployed in scattered fashion in greenfield areas. However, the future of fibre and its economic impact remains questionable. Some local initiatives have driven fibre rollouts based on political agendas. There are at least 13 very different stakeholder groups in Europe interested in FTTH, ranging from local governments and housing associations to existing telecoms operators and service providers. Stakeholders in FTTH seem to be motivated by local development concerns and local politicians' desires for control. However, financial backing is uncertain.

2.4 Wireless Strategy Drivers

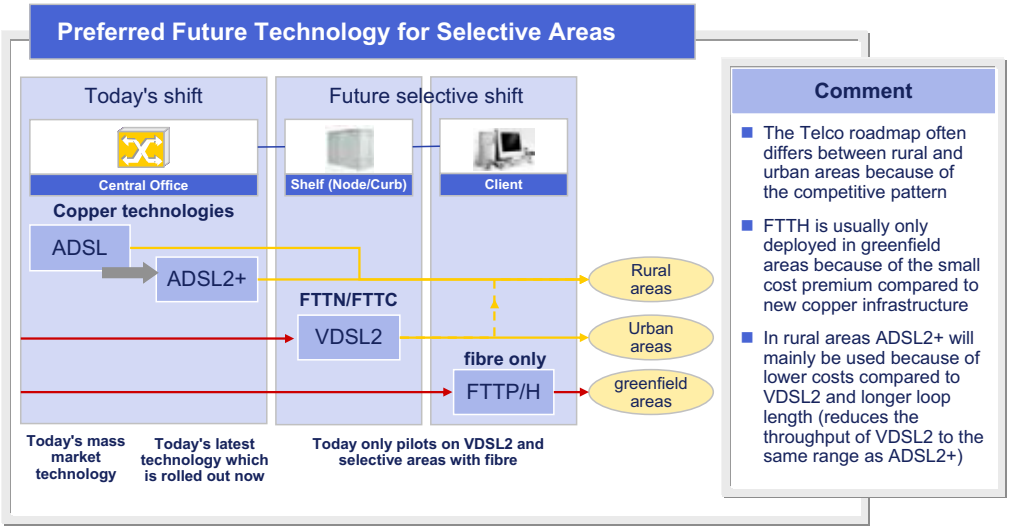
Role of Wireless in the Future – Wireless will gain in importance but will not replace wireline technologies for high bandwidth services and will therefore remain an overlay and extension network (especially for high bandwidth services such as video services). Wireless can be part of a fixed infrastructure as well as support mobility if the handoff feature is included. Especially in markets where the demand for Broadband internet services will remain in the range of 1-4Mbit/s, wireless products will cause substitution in this product area. In 2010, mobile devices (PCMCIA cards, handsets, wireless modems and embedded chips in notebooks) will only support Broadband bandwidth of up to 10Mbit/s, despite the availability of mobile standards exceeding 100Mbit/s. However, we believe that the throughput will stay below 10Mbit/s due to technical handset limitations and capacity sharing.

NGN Models and Development

What will constitute a next generation network for the operators? In this section we answer this question from a technology (upgrade) perspective and from the perspective of the amount of investment needed.

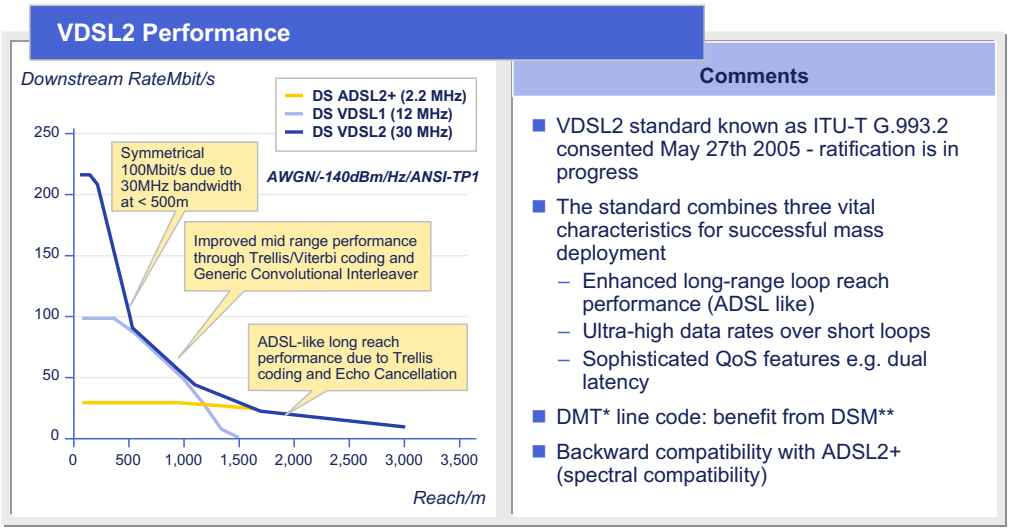
2.5 DSL Access Infrastructure Model

Dominant DSL Incumbent Access Technology – ADSL2+ will be the major technology in the next few years because it is easier and cheaper to deploy than VDSL2. In rural areas in particular, it will suffice for DSL incumbents to shift from ADSL to ADSL2+. Increasing VDSL2 coverage will lead to offerings of bandwidths around 100Mbit/s per household; this roll out will mainly focus on urban areas. This development will shorten access loop length, enhance financial attractiveness and intensify competition, mostly due to the high cable penetration.



Comment: red: fibre; yellow: copper; FTTN: fibre to the node; FTTC: fibre to the curb; FTTH: fibre to the home; FTTP: fibre to the premises

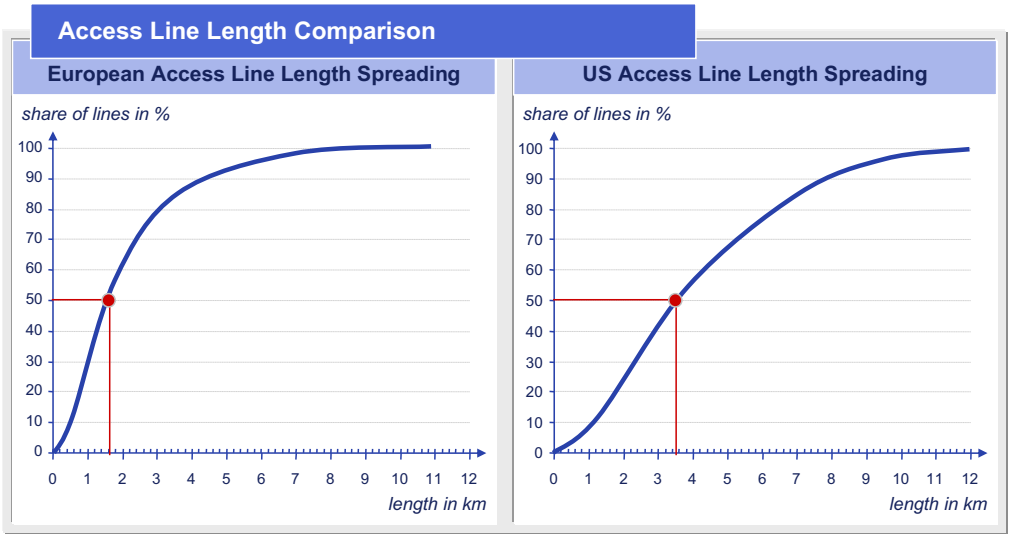
xDSL Capabilities – More effective modulation methods and better frequency spectrum usage with VDSL2 enable very high access speeds over copper cables. Because the effect of these methods is greatest over shorter loop lengths, the access nodes (DSLAMs) often need to be located closer to the customer (FTTC/N), which may require significant additional investments. At longer loop lengths, VDSL2 loses its advantage when compared to ADSL2+ (as shown in the next figure):



Sources: Telenor, Arthur D. Little Analysis; Comment: * Discrete Multitone, **Dynamic Spectrum Management
FTTC: fibre to the curb; FTTN: fibre to the node

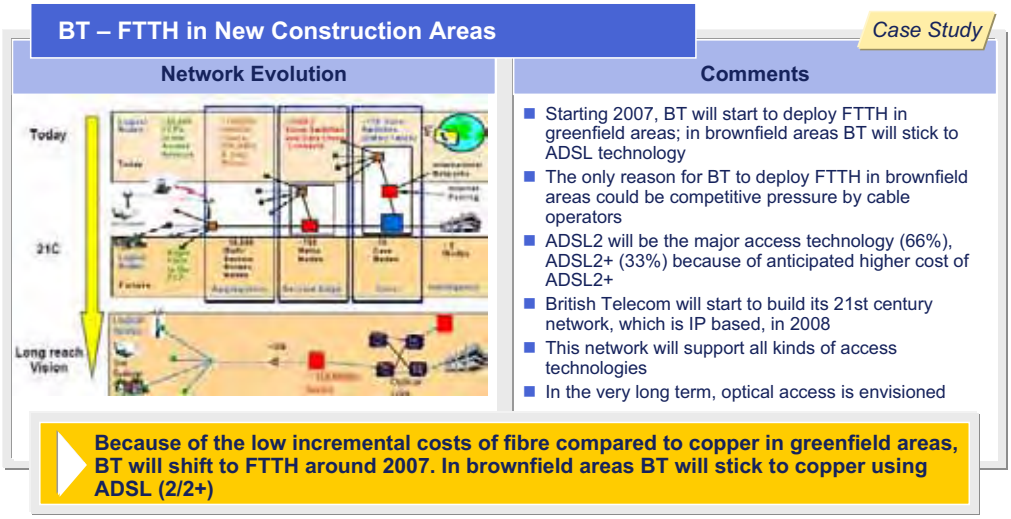
This high dependency of bandwidth on the copper line length leads to varied initial situations for up-grading the access network in different countries. For example, the median copper line length in the USA is around 3.5km; the median line length in Europe is around 1.6km; in the USA, an upgrade with DSL technologies is, therefore, less attractive in terms of reachable bandwidth than in Europe. This results in higher investment being needed in the USA to introduce Broadband services. Because some investments have to be made anyway to bring fibre closer to the customers, many operators in the USA go all the way and choose Fibre-to-the-premises (FTTP) right from the start to

differentiate themselves from other operators (see next figure regarding the line length comparison):



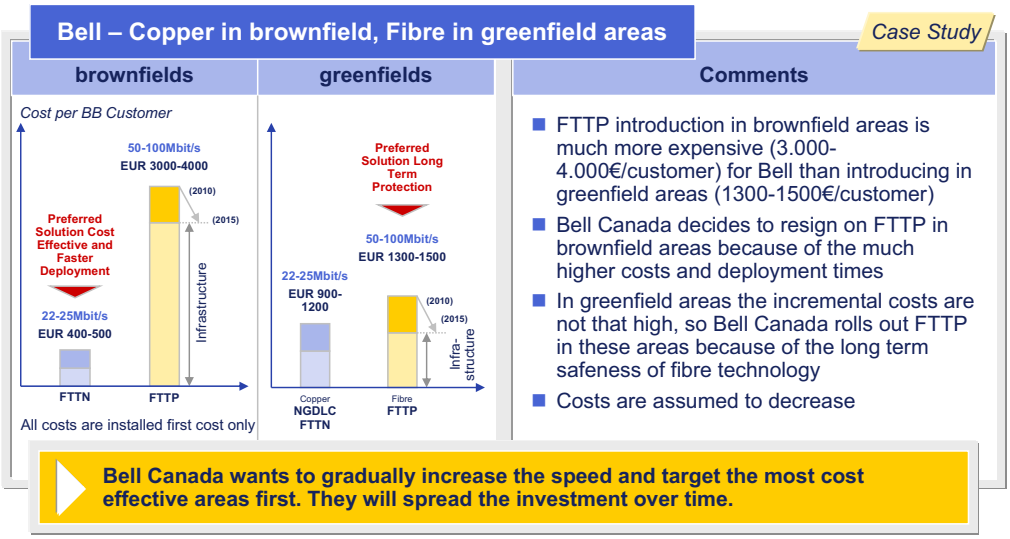
Arthur D. Little Analysis, newstreetresearch

Case Studies for DSL Incumbents Focusing on FTTH in Greenfield Areas – British Telecom (BT) will continue using ADSL (2/2+) as the access technology for their Broadband offering in brownfield areas and starts to deploy FTTH in selective greenfield areas in 2007.



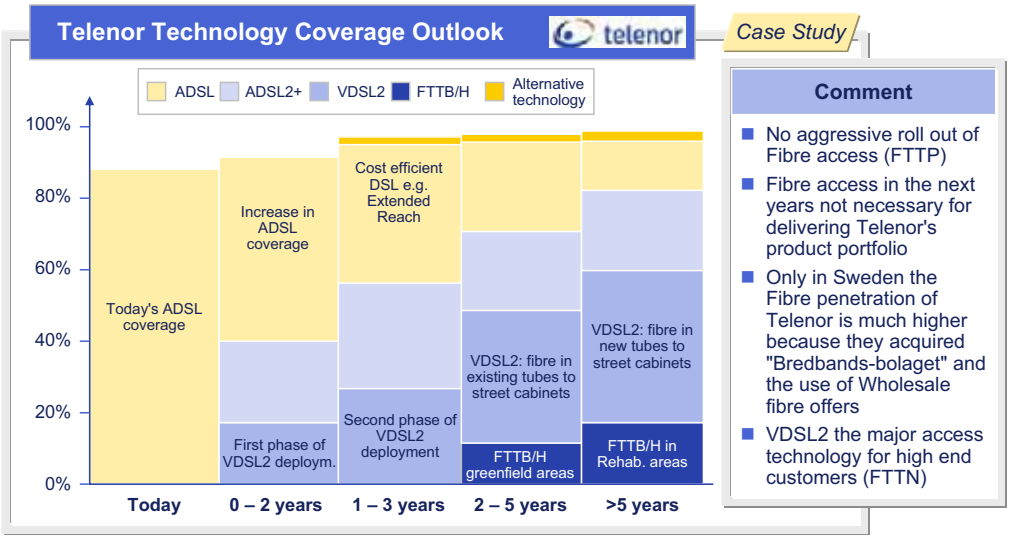
Sources: Publicly available conference presentation from BT, Arthur D. Little Interview March 2006

Bell Canada will deploy fibre only in greenfield areas and will rely on evolutionary copper paths for brownfield areas, leveraging cost advantages.



Source: Publicly available conference presentation from Bell, June 2005; NGDLC: Next Generation Digital Loop Carrier

The Norwegian incumbent "Telenor" is another example of a telecom operator that intends to reduce investment risk by sticking to existing copper infrastructure as long as feasible. In Telenor's strategy, fibre-to-the-customer is also foreseen only in select greenfield areas because it can deliver its product portfolio over the cheaper copper access infrastructure. Based on this strategy, Telenor expects less than 20% Fibre-to-the-Building (FTTB) / Fibre-to-the-Home (FTTH) coverage within its access network infrastructure in Norway by 2011 (see next figure):



Source: Publicly available conference presentation from Telenor, Arthur D. Little Interview March 2006

2.6 HFC Access Infrastructure Model

The New Standard EuroDOCSIS 3.0 – One important measure will be the introduction of the EuroDOCSIS 3.0 cable modem platform in 2007/8, which will increase bandwidth roughly by a factor of 4 up to 200Mbit/s per channel as compared to EuroDOCSIS 2.0 (see next figure):

EuroDOCSIS Development

	Euro-DOCSIS 1.0	Euro-DOCSIS 1.1	Euro-DOCSIS 2.0	Euro-DOCSIS 3.0
Services				
Broadband Internet	✓	✓	✓	✓
Tiered Services		✓	✓	✓
VoIP		✓	✓	✓
Video Conferencing			✓	✓
Commercial Services			✓	✓
Roaming Services				✓
Entertainment Video				✓
Consumer Devices				
Cable Modem	✓	✓	✓	✓
VoIP Phone (MTA)		✓	✓	✓
Residential Gateway		✓	✓	✓
Video Phone			✓	✓
Mobile Devices				✓
IP Set-Top Box				✓
Downstream Bandwidth				
Mbit/s/channel	40	40	40 (50*)	200
Gbit/s/node	5	5	5	6.3
Upstream Bandwidth				
Mbit/s/channel	10	10	30	100
Mbit/s/node	80	80	170	450

Comment

- Specification today in draft status
- A intermediate Cisco Wideband Solution (bundling of Downstream channels) could be implemented Q3/2006 for areas with high competition
- Implementation of EuroDOCSIS 3.0 is expected in 2008/2009
- EuroDOCSIS 2.0 delivers 30Mbit/s channel and 170Mbit/s per node of upstream capacity
- EuroDOCSIS 3.0 delivers 100Mbit/s per channel and 450Mbit/s per node of upstream capacity, and 200Mbit/s per channel and 6.3Gbit/s per node (based on 256QAM) of downstream capacity

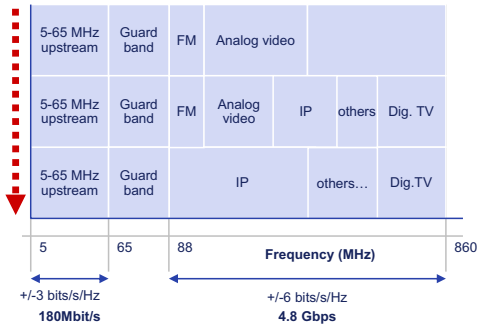
* Comment: where already QAM 256 is implemented; Source: Arthur D. Little Interview

Modulation and Segment Size Measures – A further measure is the shift from QAM 64 to QAM 256 modulation, which can already be implemented in earlier EuroDOCSIS networks, where it increases the bandwidth per channel from around 40Mbit/s to 50Mbit/s. Because the cable access network is a shared medium, one very effective measure for increasing bandwidth is the reduction of segment sizes (number of customers sharing one coax line). This can be done by splitting fibre nodes (up to 8 cables with their group amplifiers can be connected to one fibre node). However, the effect of cutting the number of households per fibre node in half, for example, not only doubles the total shared band-width but also doubles the shared access costs per customer.

Reorganizing the Frequency Spectrum – Because the total frequency spectrum of the coax cable is shared by many analogue and digital services (TV, radio, voice, Broadband internet, etc.) reallocating the frequency bandwidth has a big impact on the available capacity per product and thereby on the configuration of the product offerings. This goes along with strategic conflicts between these service groups and is also influenced by regulatory bodies, who insist on continuation of services such as analogue TV for the next few years. However, successively reducing the number of analogue video channels until they are switched off completely will free capacity for new innovative services (see figure below):

Reduction of analogue TV Channels

Frequency spectrum



Comments

- A big part of the downstream band is used by current legacy analogue video
- A successive reduction of TV channels from 38 to ~6 in 2011 will open new channels for other services like IP (total switch off analogue TV in many countries not possible based on regulation)
- Analogue TV channels require more bandwidth than digital
- VoD spectrum will increase for supporting from 40 concurrent channels to around 216 channels
- HDTV will be implemented with MPEG4 (>8Mbit/s per stream) middle 2006 (starting with Football world cup)

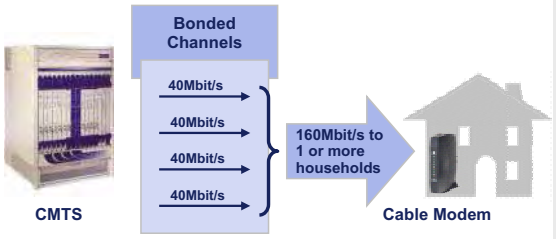
The frequency spectrum allocation to the different services are strategic decisions implicating the different service designs

Source: Arthur D. Little Interviews March 2006

This flexibility of reallocating the frequency spectrum will enable cable operators to introduce HDTV easily on the coax access line. This will give them a competitive advantage because market demand for HDTV is expected to increase while prices of HDTV equipment are expected to fall.

Channel Bonding – Cable operators can further increase the IP capacity by bonding multiple physical EuroDOCSIS channels into a single, virtual, high-bandwidth channel (as shown in the chart below):

Channel Bonding



Comments

- Without channel bonding a single cable modem can access only a single channel, and thus it cannot receive more than 40Mbit/s (with EuroDOCSIS 2.0)
- Channel bonding enables higher data rates by creating a single "logical channel" composed of multiple 6MHz channels
- Therefore the cable modem needs to be able to receive data from multiple 6MHz channels in parallel. It needs the ability to re-order the data packets to reflect the order in which they were received by the CMTS
- Channel bonding enables increased throughput between a cable modem and a CMTS by sending packets on multiple streams at the same time. It uses a flexible, packet-based algorithm for combining the capacity of multiple upstream or downstream channels to achieve the equivalent through put of a wideband channel

Source: Motorola; CMTS: Cable Modem Termination System

All IP Case Study Essent Kabelcom – An alternative option to EuroDOCSIS is to run Ethernet over the coax cable and to provide the customer with services running only over IP. This offer is based on an end-to-end Ethernet network that does not support analogue services. One example is Essent Kabelcom, which is already running an ETTH trial with 10Mbit/s connections in Boxmeer (Netherlands). Now Essent Kabelcom wants to deploy a residential access solution based on Ethernet to the home (ETTH) over the coax cable infrastructure with 100Mbit/s, enabling triple play IP solutions (see figure below):

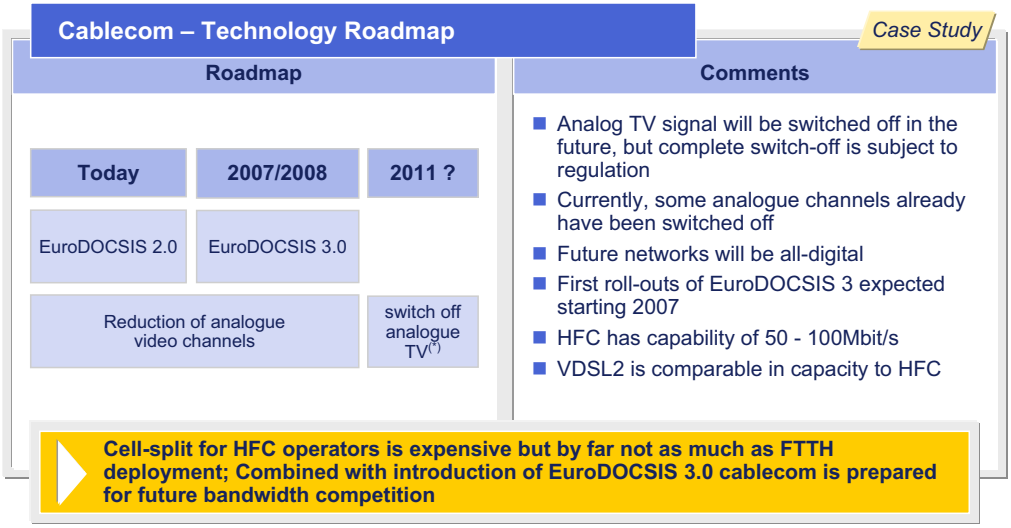
Essent Kabelcom

Case Study

- Essent Kabelcom already offered in the cable television network of Boxmeer (Netherlands) during a trial ETTH with 10Mbit/s connections
- Cable subscribers use their existing cable connection, without any active modem device in the home, to access Internet with a symmetrical speed of 100Mbit/s
- ETTH over cable is an alternative to DOCSIS/Euro DOCSIS based solutions. The ETTH system is a end-to-end Ethernet network supporting triple play IP solutions.
- The offering includes products for transportation of Ethernet data at very high speeds (up to 100Mbit/s) from optical node to strategic locations in the coaxial cable plant (referred to as Mini-POPs).
- Essent Kabelcom today offers solutions in the areas of analogue and digital TV and radio, broadband Internet, telephone services and business applications

Source: Company information Essent, Teleste

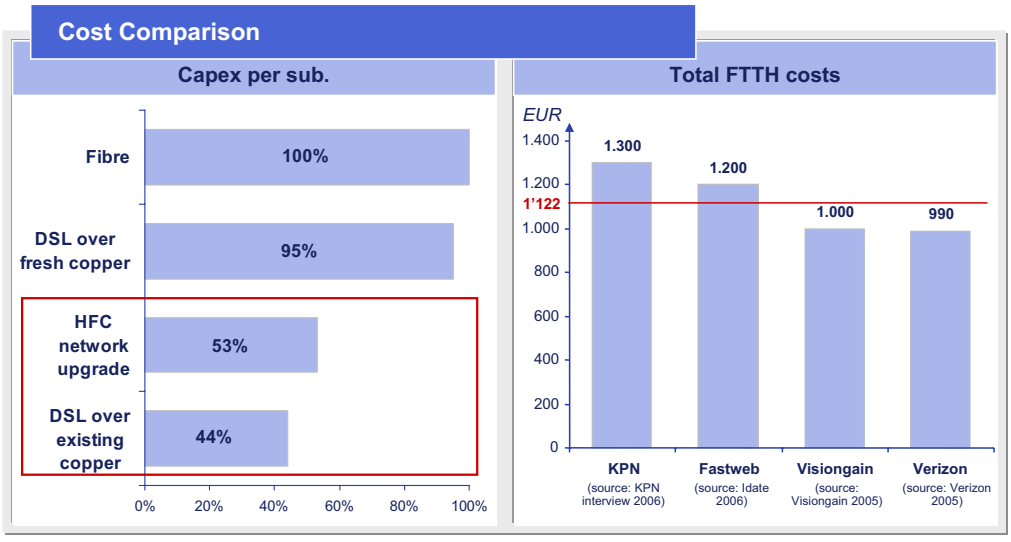
Cablecom Case Study – Competition in Broadband infrastructure is forcing the Swiss operator Cablecom to become one of the first operators to roll out EuroDOCSIS 3.0 technology in Europe. This initiative is stimulated by the highly competitive market in Switzerland, which is one of the countries in Europe with the highest Broadband penetration. Cablecom also wants to turn off analogue services as quickly as possible to run fully digital services over the cable access network. In general, this approach is in line with the strategy of all cable operators concerning an all-digital future, which will enable band-width-rich services due to the high theoretical transmission capacity over coax cables (>6Gbit).



Source: Arthur D. Little Interview March 2006; (*) comment: depending on regulatory conditions

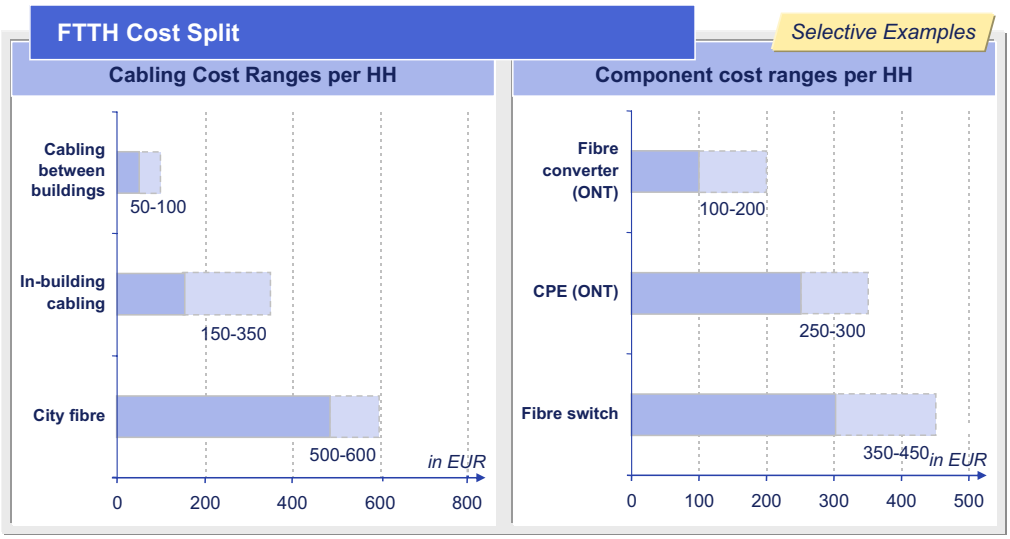
2.7 FTTH Access Infrastructure Model

Cost Comparison of Fibre Deployment with Traditional Access Infrastructure – Because copper and in many countries coax access infrastructures are already deployed to the customers' premises, the business case for deploying fibre has to be viewed from a different angle; operators compare the costs of deploying new fibre access networks with the costs of upgrading the existing access networks. Because the costs of deploying fibre are twice those of upgrading the copper and coax network with new technologies, FTTH may only be an attractive option for operators in greenfield situations (see next figure):



Source: Communications today

Cabling costs (e.g. in-building) are a large part of FTTH deployment costs, which show large differences due to great variations in conditions within buildings.



Source: Ventura Team LLP, January 2006; ONT: Optical Network Termination

FTTH Models – Two FTTH access models exist; the wholesale model and the retail model. In the wholesale model, network operations and service provision are separate, whereas in the retail model, one operator has the overall responsibility. Typically, local governments, cities and housing associations choose the wholesale model, where DSL incumbents or ISPs can provide their product portfolio over the fibre infrastructure to the customer; therewith local governments and others do not have to build product platforms and service expertise, focusing only on implementing the basic fibre infrastructure.

FTTH Market Models	Description	Illustration
1 Wholesale Model	■ Network operations and service provisioning are clearly split between parties ■ The network is open for service providers on equal terms of access ■ Infrastructure is built and then leased to private network operators that ensure access to external parties ■ Fibre is considered as a 'utility' similar to power, water and roads	Service Provisioning Service Provisioning Network Operations (Open Network)
2 Retail Model	■ One party owns the network operations and service provisioning process ■ The network is open only to a certain extent (e.g. for Internet Applications) ■ Typically carriers are using their own infrastructure ■ The network is considered as a private investment that is leveraged for return	Network Operations & Service Provisioning

Source: Arthur D. Little Analysis

From a global perspective, the role of FTTH differs in the conditions of the analyzed countries. FTTH is marketed in the US by some telephone companies and others mainly as a product differentiator compared to cable operators. In Japan, it is an access option for high-end customers. And in Europe, on the other hand, it serves as a mark of prestige.

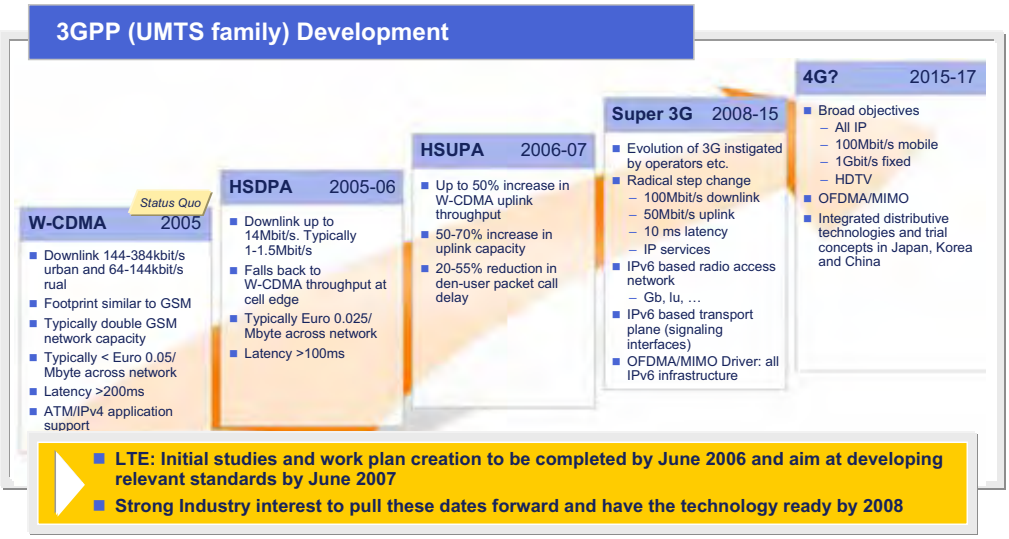
	United States	Japan	Europe
Role of FTTH	*"Differentiator for Operators"*	*"Access Option of Incumbent"*	*"Prestige for municipalities"*
FTTH status	■ Competition Model dominated ■ FTTH market is catching up since 2005 ■ Operators are using FTTH to differentiate from cable operators	■ Competition Model dominated ■ Leading FTTH market (available since 2001) ■ 4,3m FTTH homes connected middle of 2005 ■ FTTH net adds exceeding DSL	■ Open Model dominated ■ Minor FTTH footprint and early stage of development ■ Few private FTTH cases ■ Getting more attention driven by Public Private Partnerships
Reason why	■ Cable dominates Broadband markets (59% in 2004) even if the gap is reducing ■ Local loop length in the US ■ No unbundling obligations for FTTx infrastructure	■ High concentration of population ■ Majority of inhabitants live in apartment buildings ■ Long "fiber tradition" ■ Air connection possible	■ Balanced market powers between incumbents and cable operators ■ Well developed existing infrastructures (HFC and DSL) ■ Regulatory uncertainty
Examples	■ Extensive FTTH roll-outs: Verizon (clear FTTH strategy) ■ Verizon has 150k homes connected and 3m passed in 1H2006 ■ 15Mbit/s cost 40 Euro/month	■ Extensive FTTH roll-outs: NTT, USEN (and various resellers) ■ NTT has 2,7m homes connected in Oct 2005 (38bn Euro investments until 2010) ■ 100Mbit/s cost 40 Euro/month	■ Leading local FTTH operator Fastweb (Italy) and Bredbandsbolaget (Sweden) ■ Fastweb has 793.700 clients at the end of March 2006 ■ 100Mbit/s cost 34 Euro/month (Bredbandsbolaget Sweden)

Sources: iDate, Heavy Reading, Corning, ING, Arthur D. Little

Fastweb FTTH Case Study – Fastweb is one of the most successful commercial FTTH operators in the world; it is no longer deploying fibre only and uses DSL, depending on the variety of local conditions which affect the economics of FTTH. Fastweb (formerly eBiscom) was founded in 1999 and is the largest alternative fixed Broadband operator in Italy (Milan). Fastweb provides "triple play" services to all market segments in the retail and business arena through its own fibre-based network. Fastweb has complemented its fibre optic network with Unbundling of Local Loop (ULL) where fibre is unprofitable. About 35% of the customers are connected via fibre; the generated ARPU of Euro 903 per year for residential customers ranks among the highest of European Broadband.

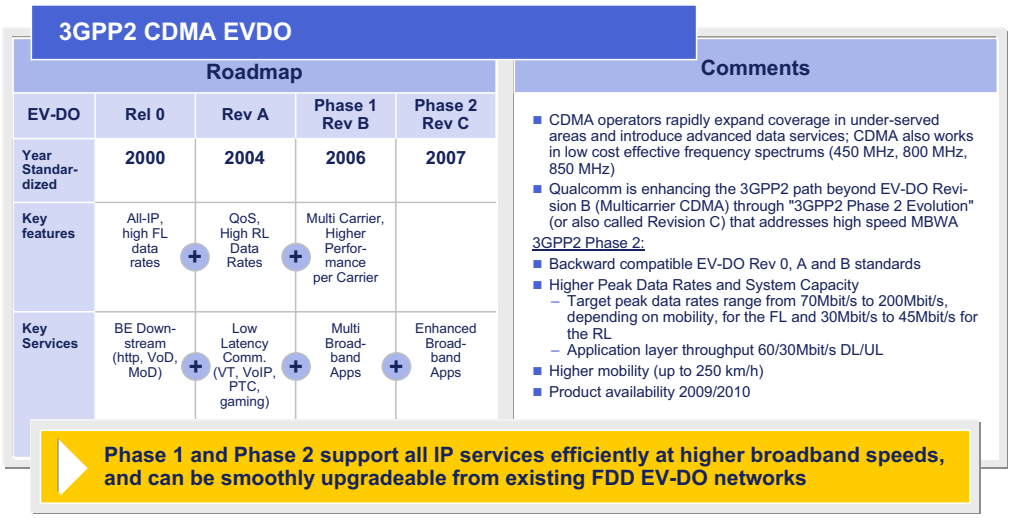
2.8 Wireless Access Infrastructure Model

UMTS family (3GPP) – The UMTS standard will develop via HSPA to LTE (Super 3G) by the year 2010, reaching around 100Mbit/s downlink and 50Mbit/s uplink capacity and having an IPv6-based transport layer. Development of the 3GPP standard is detailed in the figure below:



Note: TD-SCDMA, Edge Phase 2, HSDPA 2 are not indicated

CDMA family (3GPP2) – CDMA2000 1XEV-DO technology has been launched by many operators around the world to meet the growing demand for Broadband services quickly and cost effectively. In Western Europe, the presence of 3GPP2 is marginal due to the dominance – or in some countries exclusivity – of existing GSM networks (3GPP-family) and their migration towards UMTS/HSPA. The 3GPP2 standard will evolve to support peak data rates between 70Mbit/s to 200Mbit/s in 2009/10.



Comment: Status January 2006, Source: Qualcomm, CDMA development group

WiMax – Up till recently, WiMax had been limited to trials and pilots with no major roll out. In mid-2006, however, a first order was placed in Pakistan for the "e" standard (the so-called mobile standard). By the end of the year, Motorola will roll out WiMax to a large altnet in Pakistan's three main cities.

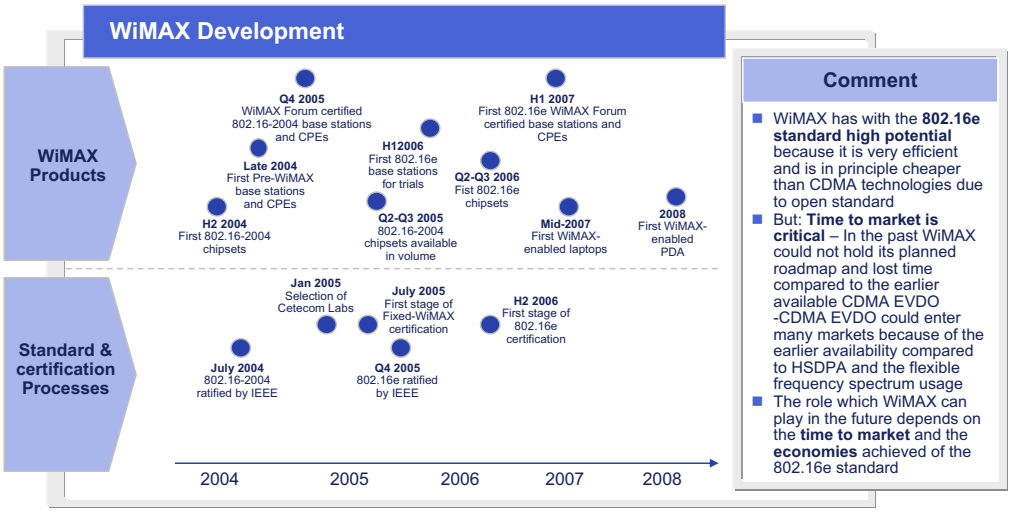
	Fixed WiMAX (802.16d)	Mobile WiMAX (802.16e)
Standard	IEEE 802.16-2004	IEEE 802.16e
PHY (excerpt)	256 FFT OFDM	512 FFT SOFDMA
Channel Sizes	3.5 MHz, 7 MHz and 10 MHz	3.5, 5, 7, 10, 20 MHz
Duplex Method	FDD, TDD	FDD, TDD
Convergence Layer	Ethernet (Layer 2)	IP (Layer 3)
Application Scenarios	Fixed and Nomadic	Portable and Mobile
Client Form-Factor	Outdoor CPE, Indoor Desktop Modem	Laptop Card, USB, Mini-PCI (for Laptop), PDA, Handset
Modulations	64 QAM on Uplink and Downlink	64 QAM on downlink, 16 QAM on uplink
System Features	Transparent Bridging, Nomadic Roaming, Self-Install	Handover Support, Paging, Sleep Mode
Mandatory Radio Techniques (in later Certification Waves)	Tx and Rx Diversity, Uplink Sub-channelization	AAS, MIMO

Source: Kapsch/ADL analysis

As 802.16e already seems ready for orders, 802.16d is today no longer an option for rolling out a new infrastructure, not even for fixed Broadband only, due to economies of scale and CPE availability/price with the "e" standard. All large incumbent vendors have moved directly to the "e" standard.

In Korea, the most advanced mobile Broadband market in the world, KDDI and Korea Telecom (KT) are considering multiple platforms in parallel, mainly to alleviate capacity problems. Both operators have clear roadmaps (on network and CPE) for integrating WiMax into their network access strategy. KDDI with its B3G ("Beyond 3G", super high speed multimedia) is already working on PDA and handsets devices that will support EVDO Rev. A + WiMax + WiFi in trials. A combination of unicast, multicast and broadcast technologies could soon make it possible for the end user to watch 2-3 videos in parallel in multiple tickers plus portal in a single seamless service. KT is integrating technology in the same way and even adding DMB in parallel to all the above mentioned technologies.

However, there are also large uncertainties with regards to spectrum; Asians, for example, are struggling enormously with allocating frequencies. Uncertainty exists in the majority of the market whether to go with the 2,4 Ghz, 3,4/3,5 or 3,6 Ghz band; the regulating authorities have completely diverging views, which makes it difficult and costly to get handsets that support the bands chosen by the regulators.



Source: Arthur D. Little Analysis

In contrast to KDDI and KT in Korea, StarHub in Singapore (the second mobile operator) believes that WiMax does not make economic sense in its home market due to high WiFi penetration, short commuting times and excellent fixed Broadband infrastructure. As a quadruple play operator, they plan to launch HSDPA and will moreover upgrade their fixed-line HFC network to the EuroDOCSIS 3.0 release within the next weeks. This enhancement will enable StarHub to offer 100Mbit/s services and as such, they are trying to pre-empt any FTTH rollout.

In purely mobile Broadband access and penetration, Europe is in a good position. Particularly in countries such as Austria, the Czech Republic, Ireland, Portugal and Slovakia, where at least three MBWA platforms are competing against each other (HSDPA, EVDO, IPW, F-OFDM, etc.) and where mobile Broadband services are already commercially available with encouraging uptake figures.

Part 3 **NGN Competition Rating**

In Part 3 we compare the infrastructure roadmaps developed by various Broadband infrastructures. This section is designed to be instructive for the purpose of forecasting the competitiveness of a variety of competing and sometimes complementary network architectures. These include cable and telecom enhancements and migration paths, full fibre network operators and mobile wireless operators, in a next generation Broadband scenario.

To forecast the competitiveness of different network technologies in a next generation Broadband scenario, we have developed two key indicators:

- Architecture/Infrastructure Roadmap
- Technology Competitiveness

By rating the different access technologies (ADSL 2+, VDSL2, EuroDOCSIS 2.0, EuroDOCSIS 3.0 and FTTH) against these key indicators, we can show the extent to which the different access technologies will be able to deliver on a number of key NGN business drivers and next generation Broadband market requirements, including:

- Ability to provide (specified) current and future Broadband products and services
- Offer (specified) seamless connectivity solutions
- Ability to offer QoS

We do not currently regard a single technology as being *universally* superior to the others in providing future Broadband products and services. The competitive advantage of a technology depends on the *usage scenarios*. Therefore DSL could become the multi-service and HFC the video-centric technology platform. HFC and its standard EuroDOCSIS (Data over Cable Interface Specification) have strengths in high bandwidth broadcasting services with add-on interactive IP services, whereas the xDSL (Digital Subscriber Line) technology is stronger in Europe (though not in the USA or India) if positioned as a basic IP access infrastructure supporting on-demand services. Competition in fixed infrastructure (DSL, HFC and FTTH) is stimulating the capacity and throughput growth. As a result, the key competitive element is fast transition from network-centric service to seamless access anytime anywhere and then to seamless integrated converged services. Convergence has two dimensions; technology and service. While DSL incumbents often have a strong position for technology convergence (fixed and mobile network), the cable operators are better positioned for service convergence (video, data and voice) as they have access to content and a relative cost advantage.

Incumbents' and cable operators' network roadmaps should adjust access flexibly and backhaul infrastructure investments according to carefully monitored bandwidth requirements. Incumbents will soon need to decide between ADSL2+ and VDSL2 for brownfield areas as well as between xDSL and FTTH technologies for greenfield areas. By contrast, cable operators should pay serious attention to converged services and need to think carefully about developing a mobile strategy if they have not already done so. ROI concerns still hinder most stakeholders in bringing FTTH deployment beyond the trial stage into mass market deployment. Current local government FTTH initiatives do not seem to make economic sense in many if not most circumstances. In fact, they may even have a negative effect on the overall deployment of Broadband in some areas, due to the

creation of overcapacity and the threat of fierce price competition which undermines the returns on all Broadband investments. Due to capacity limitations, wireless access networks do not directly compete with fixed next generation Broadband networks. However, mobile-enabled fixed next generation networks will have a competitive advantage over stand-alone fixed networks.

3.1 Technology Comparison Indicators

To forecast the competitiveness of different network technologies in a next generation Broadband scenarios, we have developed indicators for the two categories of "Architecture/Infrastructure Roadmap" and "Technology Competitiveness".

First Set of Indicators – The first set of indicators is for the category "Architecture/Infrastructure Roadmap"; it covers level of fibre density/penetration, scalability, interoperability and standardization, latency, coverage, capability of managed capacity/bandwidth, end-to-end capability and total cost of ownership.

Description & Importance: Architecture/Infrastructure Roadmap

Technical Roadmap Comparison output indicators	Qualitative Description	Importance	Reasoning of Importance
Level of fibre density/ penetration	Level, how many edge points of the network are connected with fibre		A high density of fibre penetration enables easier deployment of FTTP with less costs
Scalability	The ability to scale to support larger or smaller volumes of data and more or less users. The ability to increase or decrease size, as well as capability in cost-effective increments with minimal impact on the unit cost of business and the procurement of additional services.		Better scalability leads to more flexibility especially for smaller volumes which also has impact on economies of scale
Interoperability & standardization	Interoperability based on standardization assures flexible usage of different end-devices by the customer (not vendor dependent like proprietary technology)		Standardized technologies lead to less costs due to competition and higher variety of fitting components
Latency	For time-sensitive information across networks the transfer time from source to destination, called latency is very important (measured in s) (e.g. latency for voice calls should be less than 150ms)		Latency is especially important for interactive communication services like Voice or video conferencing
Coverage (rural/urban) & scale	The geographical reach of customers of a the network (mostly measured in % of all households)		High coverage leads to more customer potential and more flexible marketing strategies
Capability of managed capacity/bandwidth - QoS	The concept of applying and ensuring specific, quantifiable performance levels on a shared network. Performance can be assessed based on physical measurements of the network, the methods by which network traffic is prioritized, and on how the network is managed		The capability of managed bandwidth is very important, when several products are served over the same access line in parallel: some need guaranteed bandwidth, some small latency,.. whereby each product gets required technological performance
End2end capability	Performance assurance of the network from the source until the receiver (considering all potential bottlenecks and performance)		End2end capability is important for capacity rich and latency sensible products
Total cost of ownership/ sub	The cost of owning, operating and maintaining the network, broken down per subscriber share. TCO includes the up-front costs of hardware and software, plus the costs of installation, training, support, upgrades and repairs		Defines the RoI of the product

low high

Level of fibre density/penetration: Level of fibre density/penetration refers to the number of network edge points connected with fibre. A high density of fibre penetration enables easier deployment of FTTP at lower cost.

Scalability: Scalability is the ability to scale to support larger or smaller volumes of data and the number of users, the ability to increase or decrease size or capability in cost effective increments with minimal impact on the unit cost of business and the procurement of additional services. Better scalability leads to more flexibility, especially for smaller volumes, which also impacts economies of scale.

Latency: Latency is the transfer time from source to destination. For time-sensitive information across networks, short transfer time is essential (e.g. latency for voice calls, measured in ms, should be less than 150ms). Latency is especially important for interactive communication services, such as voice or video conferencing.

Interoperability and standardization: Interoperability based on standardization assures flexible usage of different end-devices by the customer and is therefore not vendor-dependent like proprietary technology. Standardized technologies lead to lower costs due to competition and greater variety of components that fit.

Coverage (rural/urban) and scale: Coverage refers to the geographical reach of network customers (usually measured in percentage of all households). High coverage leads to more customer potential and more flexible marketing strategies.

Capability of managed capacity/bandwidth – QoS: This is the concept of applying and ensuring specific, quantifiable performance levels on a shared network. Performance can be assessed based on physical measurements of the network, the methods by which network traffic is prioritized and the way the network is managed. The capability of managed bandwidth is very important when several products are served over the same access line in parallel; some products need guaranteed bandwidth and others some small latency. Therefore it is important that each product gets the required technological performance.

End-to-end capability: End-to-end capability is the performance assurance of the network from the source to the receiver, considering all potential bottlenecks and performance. End-to-end capability is important for capacity-rich and latency-sensible products.

Total cost of ownership/subscriber: This is the total cost of owning, operating and maintaining the network broken down per subscriber. TCO includes the up-front costs of hardware and software, plus the costs of installation, training, support, upgrades and repairs. It defines the ROI of the product.

Second Set of Indicators – The second set of indicators is for the category "Technology Competitiveness" and covers the topics of actual bandwidth, seamless access solution, ability to deliver "triple play" and "quadruple play", time to market, user experience/feature richness, personalization of services and cost and availability of CPE.

Description & Importance: Technology Competitiveness

Technical Roadmap Comparison output indicators	Qualitative Description	Importance	Reasoning of Importance
Actual bandwidth (up/and downstream)	The amount of information or data that can be sent over a network connection in a given period of time. Bandwidth is usually stated in bits per second (bps), kilobits per second (kbps) or megabits per second (mps).	high	Bandwidth is one major important parameter for services where high data volumes have to be transmitted in short time frames
Seamless access solution	Smooth hand over and no interruption for mobile uses	low	Important especially for mobile products and their usability
Ability to deliver 3play & 4play	Ability to provide on one hand enough bandwidth, and also necessary QoS with traffic prioritization and latency necessary for these services	high	This has a direct connection to the parameters bandwidth/managed bandwidth and QoS, because these services need different guaranteed technical performance
Time to market	The amount of time it takes to go from concept to initial shipment of a product	medium	Is important to be competitive (first mover advantage)
User experience/feature richness	The overall experience, a user of customer has with the product or service. In the usability field, this experience is usually defined in terms of ease-of-use. However, the experience encompasses more than merely function and flow, but the understanding compiled through all of the senses.	medium	A good user experience is important for the acceptance and the success of a product
Personalization of services	Ability of tailoring the service specifically to tthe individual requirements	medium	Personalization of services is an USP enabled through new interactive services
Cost of CPE/availability	Level of CPE costs and the time of availability of standardized CPE	high	The time when available and the costs per CPE have high impact on launch dates and first mover advantage

low high

Actual bandwidth (up/and downstream): Actual bandwidth is the amount of information or data that can be sent over a network connection in a given period of time. Bandwidth is usually stated in bits per second (bit/s), kilobits per second (kbit/s) or megabits per second (Mbit/s). Bandwidth is a major parameter for services where high data volumes have to be transmitted in short time frames.

Seamless access solution: This refers to smooth handovers with no interruption for mobile uses. It is important especially for mobile products and their usability.

Ability to deliver 3play and 4play: This is the ability to provide enough bandwidth and the necessary QoS with the traffic prioritization and latency necessary for these services. This has a direct connection to the parameters of bandwidth/managed bandwidth and QoS because these services need different guaranteed technical performance.

Time to market: This is the amount of time it takes to go from concept to initial shipment of a product. Time to market is important to first-mover competitive advantage.

User experience/feature richness: This refers to the overall experience a user/customer has with the product or service. In the usability field, this experience is usually defined in terms of ease-of-use. However, the experience encompasses more than mere function and flow; it includes the understanding compiled through all of the senses. A good user experience is important for the acceptance and the success of a product.

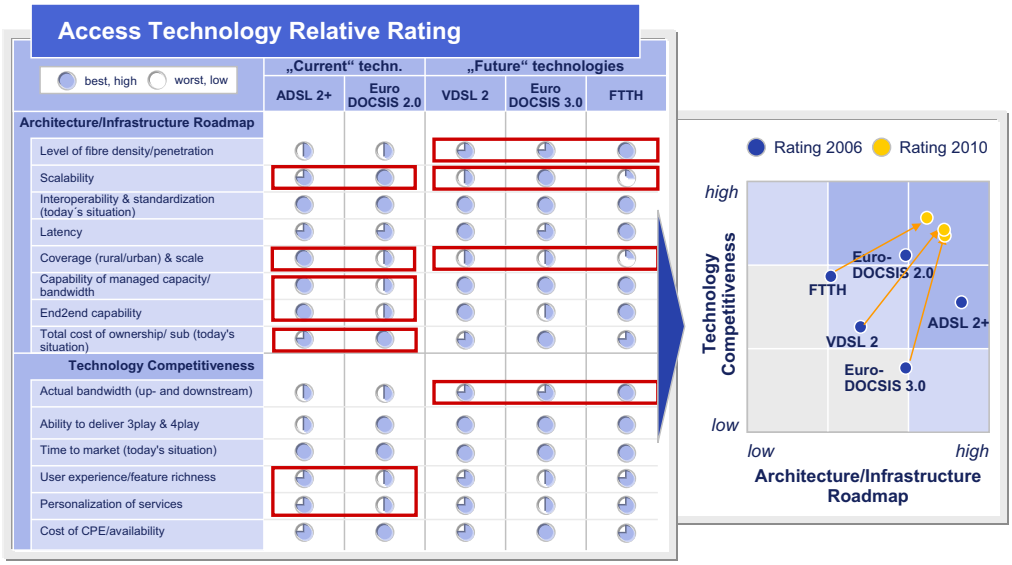
Personalization of services: This is the ability to tailor the service specifically to individual requirements. Personalization of services is USP enabled through new interactive services.

Cost of CPE/availability: This refers to the level of Customer Premises Equipment (CPE) costs and the time standardized CPE is available. The time when CPE is available and the costs per CPE have a great impact on launch dates and first-mover advantage.

3.2 Infrastructure Competitiveness Comparison

By rating the different access technologies (ADSL 2+, VDSL2, EuroDOCSIS 2.0, EuroDOCSIS 3.0 and FTTH) against the comparison indicators of the two categories "Architecture/Infrastructure Roadmap" and "Technology Competitiveness", we can reveal the extent to which the different access technologies deliver on a number of key NGN business drivers and next generation Broadband market requirements:

- Ability to provide (specified) current and future Broadband products and services
- Offer (specified) seamless connectivity solutions
- Ability to offer QoS



ADSL2+ shows the highest rating due to availability and high coverage of service. It has a medium fit for medium/high bandwidth streaming and on-demand services (SDTV) due to its high dependence on the line capacity of the loop length. Nevertheless, it has a high fit for all QoS related services (such as VoIP) due to secured quality over a dedicated subscriber line.

VDSL2 is equal to EuroDOCSIS 3.0 and FTTH but ranks behind established services like ADSL and EuroDOCSIS 2.0 due to availability, time to market and standardization. VDSL2 has a high fit for video conferencing due to its high, not shared upstream capacity and the highest fit for on-demand services (anticipating a short loop length to the customer with FTTN).

EuroDOCSIS 2.0 is slightly behind ADSL2+ due to its less extensive coverage. EuroDOCSIS 2.0 shows high peak data rates for best effort internet services, but has limited fit for on-demand products based on the shared access medium (although these limits have not been reached so far). In addition, HFC has its strength in its broad portfolio of delivered products. In contrast, it doesn't suit the technical requirements for video conferencing services, because of its limited upstream capacity.

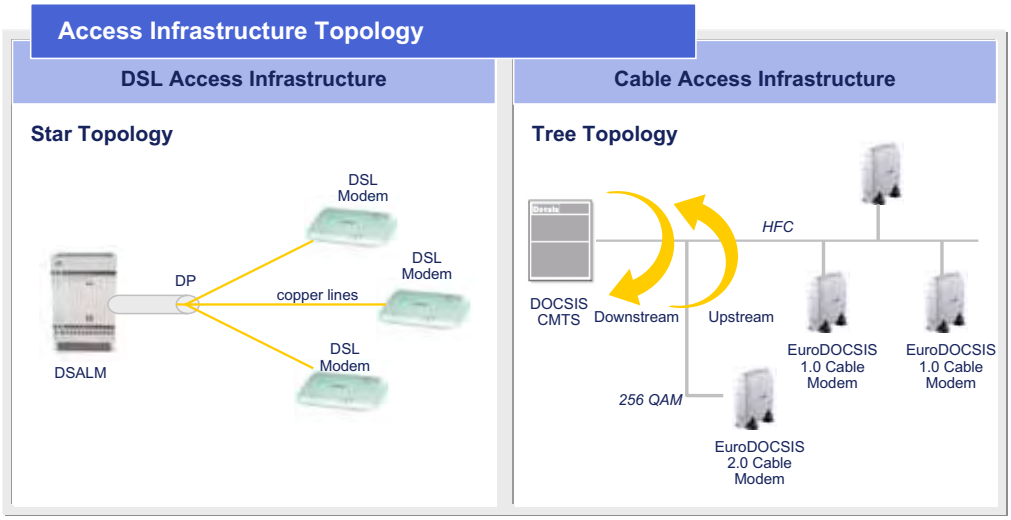
EuroDOCSIS 3.0 is equal to VDSL and FTTH, but lies behind established services like ADSL 2+ and EuroDOCSIS 2.0 due to availability, time to market and standardization. EuroDOCSIS 3.0 shows high fit for streamed bandwidth-rich services due to the network topology and optimized spectrum usage, which also results in very high bandwidth capability for Broadband internet. It shows less fit for high bandwidth on-demand services due to shared access infrastructure.

Differences between Rating 2006 vs. Rating 2010: The following indicators reveal several differences between the technology rating today and in 2010:

- **Level of fibre density/penetration** Fibre density for EuroDOCSIS will increase in the future
- **Interoperability & standardization** VDSL2 and EuroDOCSIS standards will be finalized/implemented

■ **Coverage (rural/urban) & scale**	Coverage of VDSL2 and FTTH will increase due to FTTN/FTTH deployment
■ **Total cost of ownership/ sub**	VDSL2 and EuroDOCSIS component costs will decrease, as will total cost of ownership
■ **Time-to-market**	VDSL2 and EuroDOCSIS 3.0 time-to-market will improve due to experienced technology in the future
■ **Cost of CPE/availability**	EuroDOCSIS 3.0 modems will be as cheap as EuroDOCSIS 2.0 today, FTTH will get cheaper, but not to the level of EuroDOCSIS because of less economies of scale

Topology-specific Strengths and Weaknesses of the Access Network – Due to their different topology types, DSL access networks and HFC access networks have different strengths and weaknesses influencing the product offered in the portfolio. As shown in the figure below, the DSL access network is built in a star topology, where each customer access line terminates at the DSLAM (Digital Subscriber Line Access Multiplexer). This gives dedicated customer access lines, independent of other customer usage (except crosstalk between lines). Compared to the star topology of DSL, the cable infrastructure looks like a tree (from the fibre node to amplifiers to customer modems), where each branch is shared between several customers. Therefore, this infrastructure is especially suited for broadcast services with high bandwidth needs, but offers less QoS due to the shared infrastructure.

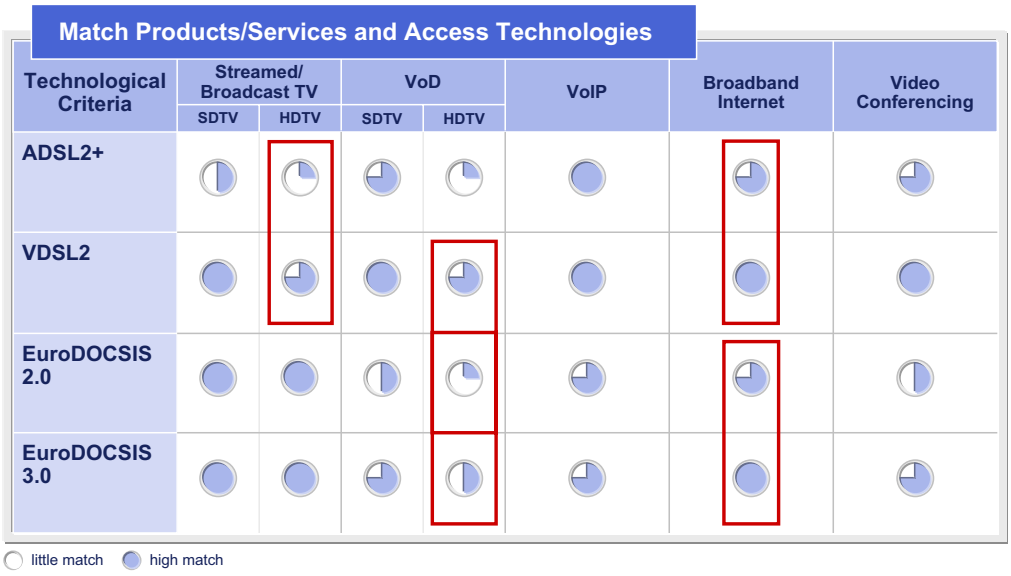


DP: Distribution Point, DSLAM: Digital Subscriber Line Access Multiplexer; CMTS: Cable Modem Termination System

Cost of Customer Premises Equipment (CPE) – The costs of CPE are another important factor in comparing access technologies. Current CPE costs vary widely with the technology standard used because established standards bring significantly lower costs than innovative new ones. However, their price typically decreases in the course of mass deployment, which is mainly driven by the effects arising from economies of scale. EuroDOCSIS 3.0 type CPEs initially cost around EUR 160 per unit, compared to EUR 5 for EuroDOCSIS 2.0 types. In contrast, ADSL-type CPE unit costs stand at EUR 35 on average, while VDSL types would be roughly EUR 110. These costs influence strategic decisions concerning the introduction date of new technologies and their

enabled services because some operators wait until the price has decreased to typical CPE values due to mass production.

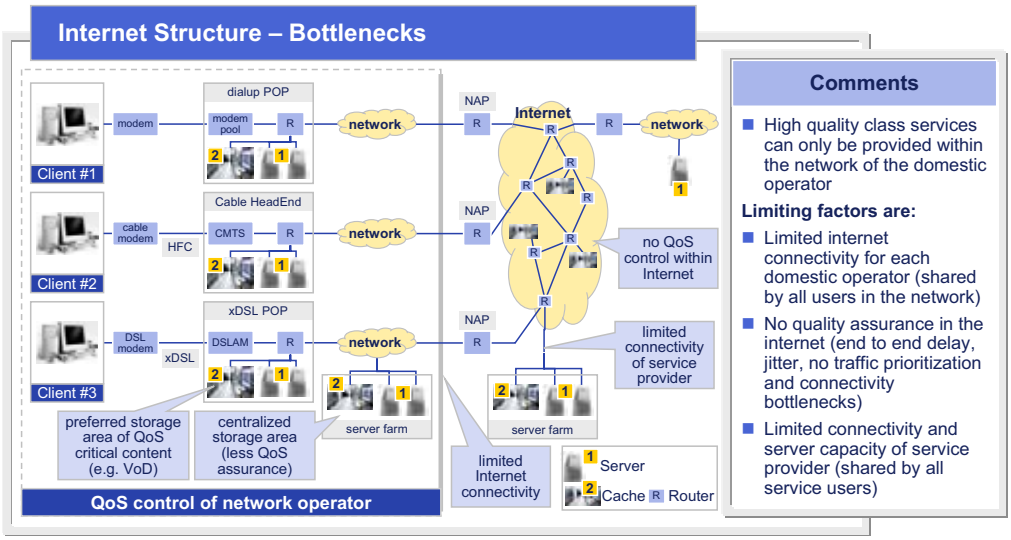
Product Focus Based on Technological Strength – Based on the topology differences described above and the different technologies used on these access networks, we assessed future high end products of typical triple play portfolios based on the following criteria: end-to-end capability, delay and latency, unicast, multicast, and broadcast capability; QoS, upstream capacity, CPE availability, and cost. Arthur D. Little has developed the following high-level framework to compare the various future generation networks which are explained in detail in our report.



As shown in the figure above, EuroDOCSIS 3.0 and VDSL2 are the most advanced technologies serving nearly all advanced future products with slight differences; EuroDOCSIS surpasses VDSL2 in high bandwidth broadcast services (such as HDTV), while VDSL2 shows benefits for high bandwidth unicast services (such as VoD) and services with QoS combined with high upstream capacity (such as video conferencing).

The capability to introduce HDTV broadcast services quickly and easily will give cable operators a window of opportunity because HDTV has high market potential in the next few years nurtured by declining HDTV equipment costs.

Providing High Quality Video Services – Players in the video segment with high-quality products can be narrowed to network providers, firstly due to the requirement of a storage location in the "home network" for high-quality realtime services and secondly because the internet currently contains numerous bottlenecks and lacks of quality assurance. Only through partnering with the access operators can additional service providers enter this market. For these kinds of services, end-to-end capability with QoS must be provided, which leads to high requirements for the edge networks (overbooking) and the video server location (see figure below):



POP: point of presence, NAP: network access Point, QoS: quality of service

In order to continue to benefit from the broad variety of its content, systems will arise that allow customers to bypass the bottlenecks in the internet by downloading video files onto local servers. The film is first downloaded and stored on the private local media server before it is viewed. Because there is no guarantee of the quality of these films (inconsistency in the quality of converting), these will cover overlay requirements (e.g. for hobbies) in addition to the high-quality entertainment content offered by network providers in cooperation with media companies.

Part 4 Public Policy and Regulatory Recommendations

What will the impact of public policy and regulatory recommendations be on the future Broadband environment? We begin Part 4 by focusing on how policy, regulatory decisions and initiatives may create incentives to invest in NGNs. Next, we elaborate on ways to allow a market-led transition to next generation Broadband. Lastly, we assess the impact these policies and regulations can have on the competitive positions of each Broadband infrastructure vis-à-vis others, which is one of the underlying pending issues in the current (2006) review of the EU regulatory framework. Our research is based on market analysis, Broadband vision and technology comparison.

To have a meaningful policy discussion regarding which regulatory regime would best support the evolution of the whole European electronic communications market towards next generation Broadband, we have to include the perspectives of all market players. After all, various differentiated approaches may be needed to strike a balance between investment risk and regulatory reward to pre-serve infrastructure (including assessment of the value of ULL) competition in a NGN era.

Based on market analysis, Broadband vision and technology comparison, the following regulatory challenges must be addressed in the current public policy discussion:

a) Stimulating market-led transition to NGNs

b) Limiting state aid for NGNs only to cases of clear market failure

c) Stimulating NGN-Infrastructure competition

d) Broadening EC's approach to market definitions – thinking 'out of the box'

4.1 Introduction

Regulatory assumptions are a key driver for NGN development

In order to remain competitive and ahead of the fundamental changes that will occur in the Broadband market up to 2011, existing Broadband infrastructure providers will be required to adapt their networks to various extents.

As infrastructure operators make the necessary investment decisions in NGNs, they must not only foresee the market developments in the near future, but also take the regulatory policy into account. The question of which regulatory regime best stimulates investments in NGNs dominates much of the regulatory and public policy debate across Europe. The pending review of the EU regulatory framework for electronic communications plays a vital role in this regard. The European Regulators Group is to adopt a report on NGN regulatory principles in 2006. Infrastructure operators are looking for a harmonized level of legal certainty that inspires sufficient confidence for making the significant investments required.

EU: Experimenting with different regulatory approaches

A number of initial regulatory approaches to stimulate investments in NGNs can be observed across Europe. These approaches reflect a dual need; on the one hand, they must strive for a balance between deregulation and greater reliance on ex-post competition law remedies, on the other, they must preserve the results yielded by implementation of the legacy exante regulatory approach contained in the EU directives (e.g. mainly competition on the basis of local loop unbundling).

Our analysis shows an emerging development towards NGNs and some telecom incumbents, including Belgacom and Swisscom, have already made firm network investment commitments in this regard. This is due, among other things, to the absence of a regulatory obligation to offer wholesale services on upgraded access networks at cost-oriented prices. Belgacom so far has not been placed under an obligation to wholesale its FTTN-based Broadband services. Swisscom in Switzerland, falling outside the EU and the scope of the EU's regulatory framework, has no legal basis for an obligation to unbundle its access lines and is therefore not expected to wholesale its FTTN-based services.

Other incumbents in more heavily regulated environments are still testing the waters with their regulators. KPN, for instance, has introduced an "All-IP" strategy. In view of the competition by strong independent ISPs created by regulation over KPN's unbundled lines, we can however be sceptical about OPTA's inclination to sacrifice its current approach completely to foster investments in NGNs by KPN. This would also apply to other NRAs in countries with a high level of regulated local loop unbundling such as France, Italy or Scandinavia. OPTA has so far stressed the importance of preserving the variety of internet access products offered by operators over the incumbent's lines due to collocation and MDF access. OPTA wants to avoid wholesale agreements on NGNs taking the shape of reseller arrangements only and may consider mandating fibre node access.

In contrast, in the UK, local loop unbundling regulation has been implemented relatively unsuccessfully. Delays in supplying fit-for-purpose wholesale products by the incumbent DSL operator BT seem to have given ULL a slow start compared to France. But BT now is already in the more advanced stages of developing a regulatory approach with its regulator. BT has agreed with OFCOM that it will establish an internal organizational structure called "Openreach" to guarantee operational separation and provision of equivalent (wholesale) products (to itself and to its wholesale customers) in order to maintain an adequate level of competition. Institutionalizing regulatory obligations through an independent organization within the BT Group (with its own P&L account) is seen as an incentive-based (self) regulatory approach to stimulate NGN development. BT however has not made any decisions as to which NGN technology it will implement.

4.2 Market Developments that Impact Policy and Regulation

We believe that any regulatory approach should be embedded in sound policy and based on a thorough understanding of the dynamics of the next generation Broadband market. By analyzing the competition in the next generation Broadband market, as well as the

key drivers behind it, we have identified a number of developments that should serve as input to new policies to support the development of NGNs and the choice of new regulatory instruments:

- **Multiple NGNs will coexist and compete**

  Although FTTH networks are often portrayed as the only future-proof infrastructure, when we compared access infrastructure technology input and output indicators, we found that by 2011 FTTH, VDSL2 (telecoms) and EuroDOCSIS 3.0 (cable) will be able to provide similar capabilities.

- **Demand for ubiquity of access takes triple play competition to the next level**

  Our analysis of the market shows that mass-deployment of the IP standard will move triple play competition to the next level; from hype to mainstream. The main evolution of the next generation Broadband market lies in demand to make next generation Broadband services seamlessly available over converged access platforms. This will require current infrastructure operators to accelerate implementation of their fixed-to-mobile convergence strategies.

- **Broadband ARPU will stabilize through value-added services**

  Cross-selling and convergent offers, not access, will be the pre-eminent drivers for ARPU growth. New revenue streams for infrastructure operators will be found in bundling Broadband connectivity with value-added IP-services and in new customer segmentation opportunities based on commercial QoS deals with IP-based service providers (such as Yahoo, Google, Apple/iPod and Microsoft).

- **Bandwidth is no showstopper**

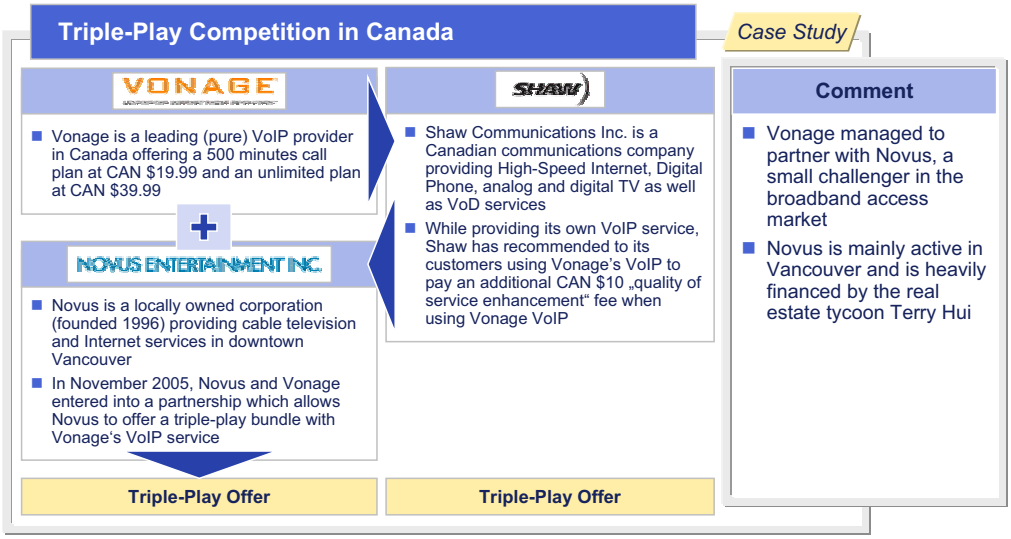
  Migration towards next generation networks is not primarily driven by bandwidth requirements. Our analysis shows that the majority of subscribers will remain in the range of 1-6Mbit/s up to 2008 and in most countries (except the Netherlands) even up to 2011. Based on current expectations of future services, we would not expect a bandwidth requirement higher than 50Mbit/s download and 8Mbit/s upload per average household in 2011.

- **Increased scope for market entry**

  Whilst existing networks were closely aligned with specific services, separate equipment and separate BSS/OSS evolved for each of those services, NGNs can use the same platform and define the services in server platforms. The proliferation of the IP standard in core and access NGN architectures, as well as in transport streams, will increase the possibilities for independent IP-based service providers to enter the market entry at very low cost. IP-based services can be seamlessly provided to or accessed over the IP-based application layers of any fixed and mobile platform. These next generation market entrants have no need for physical network access as the first generation new market entrants did. Network interconnectivity will become less relevant than IP-peering.

Next generation Broadband policies should be aimed at maximizing growth opportunities in the market. As network elements, access platforms and services become more modular and generic, new revenue streams become available. This is confirmed by the trend towards stabilizing Broadband ARPU after years of decline and commoditization.

Before infrastructure operators can be expected to commit to invest in NGNs on a large scale, however, they first need a certain amount of reassurance that public policies will preserve the value proposition inherent in the vertically integrated network operator model. This implies that they would not consider entering into any retail or wholesale obligations if they thought these could lead to disinter-mediation and a disproportionate shift of value to infrastructure-independent services providers operating over the application layer. A balance could be found by stimulating commercial arrangements for instance QoS deals between infrastructure providers and over-the-top providers; to offer innovative Broadband products in the form of attractive new customer tiers. A case study of one example of a current QoS deal is Shaw Communications, Vonage and Novus in Canada (see graph below). Unlike the USA, where the issue of "over-the-top providers" access to customers has led to calls for "net neutrality" regulations to prevent internet traffic prioritization, we believe the level of NGN-infrastructure competition in Europe will stimulate market solutions.



Source: Proprietary Arthur D. Little Broadband Research

On the wholesale side, current (interconnection) revenues of operators on the wholesale Broadband market are under pressure from direct IP-interconnection opportunities offered by alternative fixed and mobile Broadband networks. Operators will be looking towards concluding IP-peering type of agreements, whilst having to observe regulated interconnection agreements on legacy platforms. Also, traditional network access issues are changing in nature, reflecting the lack of interest in traditional physical network access by over-the-top providers.

We believe that market entry is greatly facilitated by the deployment of the IP standard. This situation calls for policies reflecting a significant level of deregulation as far as NGNs are concerned and a phasing out of regulatory obligations reflecting legacy infrastructure bottlenecks and isolated, infrastructure-related markets.

4.3 Deregulation Trend towards Sustainable Competition

> *"We expect a much stronger deregulation for European markets in the coming years. There are simply too many arguments supporting deregulation trend."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

Deregulation, as a key driver for new infrastructure investments, has become one of the hottest topics in today's telecom markets. The issue is currently being intensively discussed in many countries, mainly as a means to provide incentives for investments into new infrastructures such as VDSL and FTTx. Based on the current regulatory framework that envisions a sharing of incumbents' networks, there are only limited investment motivations for the different network owners. This is because the ROI is lower or the payback period longer than expected.

Policy makers can choose between protecting competition in static markets by regulation and accelerating competition in dynamic markets by deregulation. However, a development towards market and technology convergence, as is planned for European Broadband markets in the years to come, is much more likely to take place in dynamic markets. Higher investment incentives in a deregulated market create positive market dynamics which result in increased welfare.

> *"Increasing infrastructure competition raises consumer welfare and operators would be willing to invest in case of an adequate ROI. Thus investment should not be hindered by regulation."*
> *(Quote from interview with operators, regulators, content providers and equipment manufacturers)*

International Benchmarks for Successful Deregulation

International benchmarks highlight successful examples of deregulation measures that can be used to derive lessons learned for the European case. Countries such as the United States (see figure below) or Hong Kong have already adopted substantial deregulatory measures. With already much of its telecommunications sector deregulated, the USA is currently leading the way. Investments into fibre infrastructure have been completely exempt from regulation and obligations requiring incumbents to grant competitors access to the existing copper infrastructure have been largely reduced. These decisions by the Federal Communications Commission (FCC) are a reaction to the rapid decline of investments in fixed-line communications infrastructure over the last few years and the fear that the USA would fall behind other nations with respect to Broadband diffusion, leading to a loss off international competitiveness.

In Europe, the approach will be different and based on preserving the level of competition created by the old regulatory framework. Given the significant investments needed to migrate to NGNs, it will be critically important for national regulators to take the risk profile of these investments into account when they consider setting regulated tariffs in cases of mandated pro-competitive access obligations. For more specific information on deregulation, please see Arthur D. Little's analysis "Deregulation of the Telecom Sector and its Impact on the Overall Economy" (published December 2005).

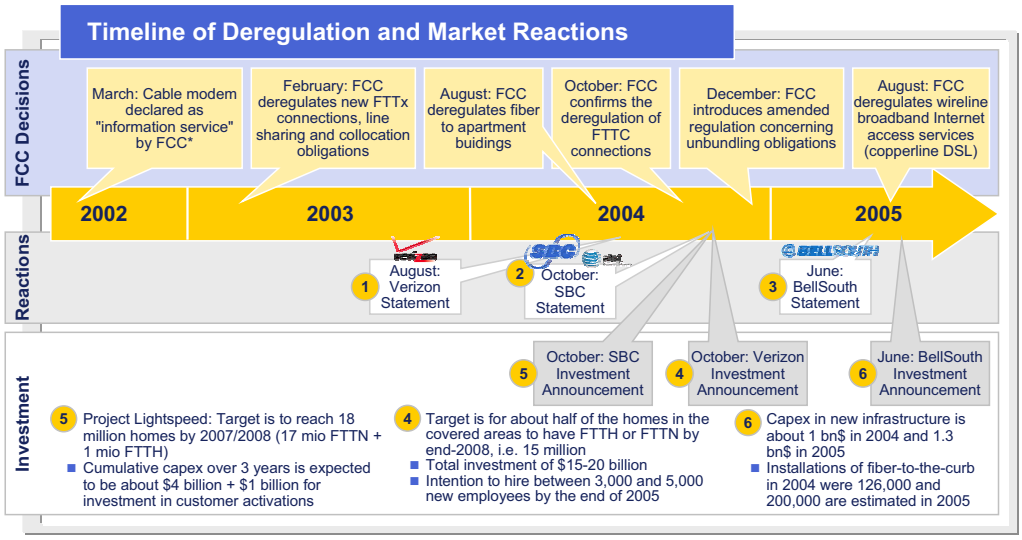
Current Deregulation Discussions

Country	Intention of Deregulation	Background/Reasoning	Status
US	■ Fade out of unbundling, line sharing and collocation obligations for broadband connections ■ No unbundling obligations for future FTTx infrastructure	■ Decline in investment ■ Imparity between cable and telco regulation	Implemented
Hong Kong	■ Fade out of unbundling obligations for FTTx ■ Ending of compulsory provision of LLU	■ Enable investments in network infra-structure to earn returns adequate to the associated risk	Implemented; LLU phase-out 2008
Australia	■ Enable potential investors to set out access terms and conditions before investment	■ Investment certainty for additional networks	Subject to approval
Canada	■ Framework for forbearance of high speed intra-exchange digital services ■ Partial deregulation of local telecom market	■ Bell Canada's application to react on pricing and fierce competition	Ongoing hearing, decision 2006
Germany	■ "Regulatory holiday" i.e. forbearance of unbundling obligation for FTTx/VDSL infrastructure investment ■ Deregulation of international calls	■ Investment incentives ■ Regulatory certainty ■ Incumbent lost significant market power in the international voice business	Need for EU approval; Affiliation in German telecom act

Source: Country regulators 2005

As shown in the US case study below, deregulation decisions by the FCC were followed by significant investment announcements; first by the telecom incumbents, followed by competitors and alternative infrastructures such as cable.

Timeline of Deregulation and Market Reactions



*In June 2005 the Supreme Court asserted the FCC's cable ruling (Brand X Case); Source: FCC – Policy highlights of Michael K. Powell's FCC Tenure (2005); FCC Press Releases and Web Site; Arthur D. Little analysis

A recent study for the London School of Economics (Robert W. Crandall, The Brookings Institutions – "USA Broadband after 10 years of Confusing (and Confused) Regulatory Policy", May 25, 2006) shows that incumbents' investments in deregulated markets in the USA and Canada exceed investments in the EU's highly regulated environment.

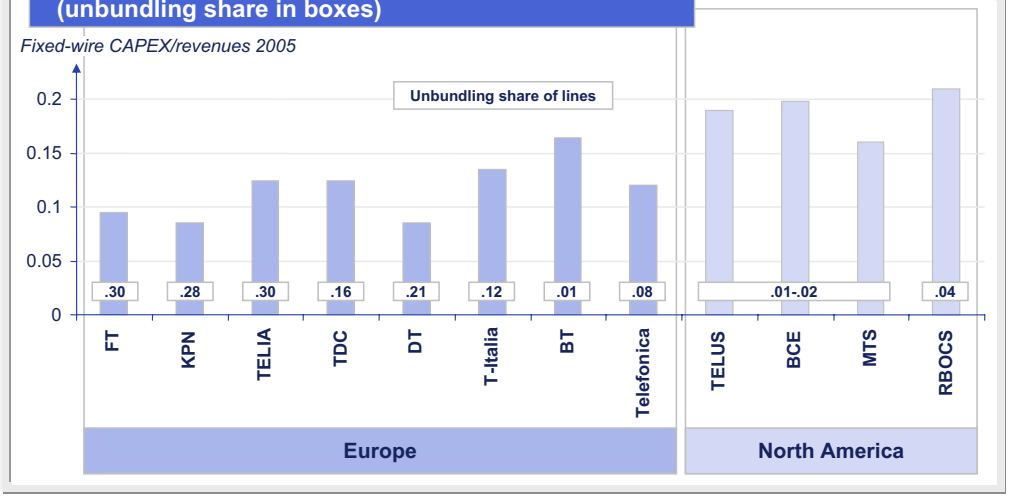
Investment Announcements by Other Market Players

examples

Company	Announcement	Details
OEN	**OEN Plans Large-Scale FTTH Deployment in Houston** … announced plans to deploy FTTH to 1,600,000 households in Houston, the 10th largest television market in the U.S. The company … plans to launch its United States service offering in December 2005 Press release, October 2005	■ OEN plans to offer integrated IPTV service, 10 to 100Mbit/s Internet, Voice, Video-on-Demand (VOD) and other broadband applications ■ OEN said it has acquired programming agreements for IPTV distribution of over 400 television channels
comcast	**Comcast Extends National Fiber Infrastructure** …to provide inter-city and metro dark fiber as part of Comcast's extension of its fiber footprint. This backbone ensures that Comcast has a technically advanced and fully upgradeable nationwide broadband network… Company press release, December 7, 2004	■ Agreement with Level 3 Communications to expand fiber footprint ■ Network expansion including fiber capacity, routing and optical equipment
COVAD	**Covad Announces 2004 Network Expansion Initiative** Covad … today announced plans to expand its nationwide coverage area and customer reach for digital subscriber line (DSL), frame access, and T1 broadband services. Company press release, January 7, 2004	■ Installation of additional broadband equipment in approximately 200 central offices across the nation, increasing Covad's nationwide broadband network to more than 2,000 central offices ■ broadening the access network enables Covad to more efficiently utilize its core ATM network

Source: Press clippings, Arthur D. Little analysis

Fixed-wire capital expenditures/revenues 2005 (unbundling share in boxes)



Source: Company annual reports

Relevance for the European NGN policy debate

Important differences between the regulatory approach in the USA and the EU make implementation of a USA-style regulatory approach in Europe less feasible. The USA, for example, adopted a "laisser-faire" policy, arguing that the negative consequences of an interventions by the regulator would out-weigh the negative impacts of dominance. Unlike the USA, the EU designed a sophisticated system of tailor-made regulatory obligations which was implemented with varying degrees of success by the EU member states. These obligations aimed to prevent incumbents from exploiting their dominant position, whilst promoting investments in alternative infrastructures. The "ladder of investment" concept was introduced as the theoretical basis to argue that alternative operators are moving up the infrastructure ladder on the basis of five regulated forms of competition, including DSL Resale, Bitstream, Shared Access, ULL as well as Naked DSL (realized either over Bitstream or Shared Access). The concept foresaw that the five options would differ in terms of scope for service differentiation compared to the offering of the incumbent and in terms of gross margin potential (resale always lowest,

ULL always highest). Although an alternative operator should always have an incentive to move up to the next rung of the ladder and finally roll out its own infrastructure, so far no real evidence of a general upward movement on the rungs of the investment ladder by alternative operators can be provided, with the exception of France.

> *"Many competitors using resale or bitstream access (BSA) offers, who entered the market years ago, are not making the necessary investment to move 'upwards' on the ladder"*
> *(Michael Bartholomew, Director European Telecommunications Network Operators' Association, Regulatory Frameworks for Promoting the Broadband Market Broadband, World Forum Europe in October 2005)*

Observations indicate that, generally, alternative operators are designing their business model around one of the five options with no intention of moving higher up the ladder. The observable consequence is that competition predominantly takes place on the existing infrastructure platform and that the overall objective of this regulatory concept is not going to be realized.

Any future NGN policy in Europe will probably nevertheless want to preserve the results of the legacy approach and sustain the level of infrastructure competition it has created. The regulatory approach to stimulating investment in NGNs in Europe will therefore need to be more sophisticated than in the USA. Nevertheless, the basic premise of deregulation seems the best way forward to accelerate investments in NGNs in Europe too. Arguments for this include the fact that the ladder concept behind the implementation of a sophisticated regime of regulated forms of competition does not appear to be working well in most European Broadband markets. Second, the basic assumption underlying the USA laisser-faire approach, namely that market forces and technology will change over time, act to counter the market power of dominant players, also seems to be becoming reality in Europe, looking at the pace of IP deployment and the changing face of competition in the next generation Broadband market.

The European Commission is expected to consider a low to medium reduction of telecom regulation in its directives from 2006 onwards. The discussion on deregulation – "yes" or "no" – is mainly being conducted on a Commission level. Most experts agree that a certain degree of deregulation will likely be brought forward by the Commission soon. This prognosis is supported by the fact that public institutions, such as the OECD, have long asserted that investments in information and communication technology have positive effects on the overall economy.

4.4 Policy and Regulatory Recommendations for the Migration Phase towards NGNs

On the basis of our analysis, we recommend a number of principles be reflected in future public policy and NGN regulations.

a) Stimulate market-led transition to NGNs

It seems inevitable that Broadband infrastructure operators will migrate towards NGNs. On the one hand, because consumers are demanding ubiquitous access and on the other hand because new market entrants (such as Yahoo, Google, etc.) are offering strong

innovation-based competition over the application layer, introducing innovative (video-based) Broadband services and applications. For telecom incumbents, the most pressing need for NGNs seems defensive (e.g. to stop the bleed on their traditional fixed line business) by achieving network-built efficiencies and opening up new opportunities for wholesale and retail IP-connected products. For cable operators, the move towards NGNs is less intrusive. Their current access networks have higher capacity and seem more scaleable on the basis of the network elements in place, although managing bandwidth due to shared capacity remains a challenge. Cable's biggest competitive problem lies outside the technology field and is related to the challenge of providing coverage when operating regionally rather than nationally as other incumbents.

We do not expect market-led migration to NGNs to take the shape of full, nation-wide, infrastructure competition between NGNs before 2011 (perhaps with the exception of Greenfield areas). On the basis of our analysis, we expect that telecom incumbents, for example, will only gradually upgrade to NGNs, though starting in those areas where they face biggest competition from cable NGNs, typically centred on the big metropolitan areas. It is therefore in this migration phase, where only local and regional pockets of NGN competition are emerging, that government-sponsored Broadband networks (like Fibre-to-the-Home initiatives in the Netherlands or wireless city networks in the Czech Republic) will have the greatest distorting effect on competition by delaying investments by private infrastructure operators. The prospect of having to compete with subsidized services over sponsored networks substantially increases the risk profile of private NGN building activity, which drives up the cost of financing NGN investments for all private Broadband infrastructure operators. We do not believe that public local networks will, if ever, be commercially viable beyond the migration phase. Their limited coverage will render them unattractive for service providers, as competing NGNs with larger scales will be able to offer access to bigger customer segments at more attractive commercial terms.

b) Limit state aid for NGNs only to cases of clear market failure

In order to stimulate a market-led transition to NGNs, we believe that public policy and regulation should limit government sponsorship of NGNs to cases of clear market failure. Market failure occurs where there is a persistent lack of any commercial incentives for private infrastructure providers to invest in building or upgrading existing Broadband infrastructures in a given area to deliver the bandwidth necessary for customers to access current- and next generation Broadband products. As our analysis shows, most existing Broadband infrastructures are already well capable of delivering the bandwidth required by next generation Broadband services. The other argument that is often quoted to justify publicly sponsored networks is that these provide a counterbalance to the dependency of customers on service offerings over existing infrastructures controlled by private parties. We believe however that competition law should remain the sole instrument for dealing with cases of alleged abuse of market power, never state aid. State aid can only be considered an option to stimulate NGNs in static, uncompetitive areas. In competitive markets, it would undermine market forces and bring market-led transition to NGNs to a grinding halt.

c) Stimulate NGN-Infrastructure competition going forward

Our analysis shows that scope exists for multiple NGNs to co-exist and compete to serve the next generation Broadband market. If we compare the various access technology roadmaps, we see that current telecom and cable networks are firmly on track to provide

innovative Broadband services. Although xDSL (VDSL2 access technology) will remain the dominant technology in Europe, cable (on the basis of EuroDOCSIS 3.0 access technology) and FTTH will provide similar capabilities. No technology can be regarded as universally superior but, depending on different usage scenarios, competitive advantages of each technology emerge leading to clear market opportunities for each of them. The current regulatory framework is based on the idea that infrastructure competition is the best way to foster investment, and we believe this should be continued. We also believe the scope for competition between various next generation networks is realistic.

d) Broaden EC's approach to market definitions – Think 'out of the box'

The current trend of fixed-to-mobile convergence of current Broadband networks plays a fundamental role in shaping NGNs. Isolated Broadband networks at present will experience a paradigm shift towards multiple, seamlessly connected and ubiquitously accessible next generation networks, supporting increased mobility of users. The current regulatory framework and the definition of relevant markets very much reflects first generation Broadband networks. It is based on a very detailed breakdown of isolated telecom markets and services and reflects the characteristics of first generation Broadband network architecture. This approach does not take into account the fundamental changes as the result of fixed-to-mobile convergence and the rationale behind NGNs. Whereas first generation networks were closely aligned with services leading to separate equipment, transport platform and support systems for each dedicated service, NGNs will use the same network platform and define the services in server platforms. As increased mobility becomes a key competitive feature for fixed Broadband networks, assessing market power on the basis of the current market definitions fails to reflect the reality of the next generation market place. At the same time, increased interconnectivity of legacy and alternative technology platforms and internet-based service providers entering the market increases the demand and supply substitutability of services and networks generally. This means that more market players will have to be taken into account when assessing the level of prospective competition and dominance findings on any defined relevant next generation market.

Appendix A **Methodology**

This report compares Western European high bandwidth countries with case studies in North America and Asia over the timeframe 2005–2011. The quantitative respectively qualitative results and conclusions in this report are based on three main sources of quantitative and qualitative data:

- interviews with industry experts,
- primary and secondary research,
- as well as a proprietary Arthur D. Little Broadband market model.

Industry expert interviews – To gain insights into key trends and corporate strategies, Arthur D. Little conducted a series of interviews and workshops with executives of leading companies in the Broadband industry. Over 30 interviews in 10 countries have been carried out with companies across the entire Broadband value chain. Among the executives interviewed were representatives of Network Service Providers and Operators, Content Providers, Device Manufacturers and National Regulatory Bodies. The interviews provided a first-hand supply-side perspective on the Broadband industry, its drivers, challenges, current dynamics and perspectives. Interviews with regulatory bodies gave additional insights into current policies towards the Broadband industry in different countries, the level of competitiveness in particular markets, as well as the impact of regulatory actions on Broadband developments under various market conditions.

Primary and secondary research – Arthur D. Little professionals conducted extensive research and in-depth analysis of the Broadband industry within each of the markets studied. Using official sources, news items and company information, Arthur D. Little gathered a comprehensive set of data. Information was collected at national, regional and company levels to compile a complete picture of subscriber numbers, access costs and key Broadband market characteristics. The data combined with in-depth country-specific market expertise, has enabled Arthur D. Little to conduct a "reality check" on reported company figures and to compile a realistic and comprehensive picture of the Broadband industry. A dedicated group of researchers was set up to co-ordinate the work of all country-based research teams, consolidate country-based analysis and address any inconsistencies. The team also carried out a second wave of Broadband market research to cross-check consolidated figures.

Arthur D. Little Broadband market model – To quantify changes that Arthur D. Little envisages will take place in the Broadband industry, we built a model capturing current industry data, industry dynamics, growth levers, drivers and inhibitors. The model provides a clear and robust view on Broadband industry development and growth over the forecast period. The assumptions used were carefully selected and tested for consistency with current industry development.

Expert perspectives from individual Arthur D. Little staff were filtered through rigorous collective debate and deliberation, producing analyses that reflect combined Arthur D. Little expertise.

Appendix B Definitions and Abbreviations

3GPP	The 3rd Generation Partnership Project is a collaboration between ETSI (European Telecommunications Standards Institute – Europe), ARIB/TTC (Association of Radio Industries and Businesses/Telecommunication Technology Committee – Japan), CCSA (China), ATIS (Alliance for Telecommunications Industry Solutions – North America) and TTA (Telecommunication Technology Association – South Korea). The scope of 3GPP is to make a globally applicable third generation (3G) mobile phone system specification within the scope of the ITU's IMT-2000 project. 3GPP specifications are based on evolved GSM specifications, now generally known as the UMTS system.
3GPP2	3GPP2 is the standardization group for CDMA2000, the set of 3G standards based on earlier 2G CDMA technology.
ADSL	Asymmetric Digital Subscriber Line is the most widely used version of DSL with higher download speed than upload.
ARPU	Average Revenue Per User
ATM	Asynchronous Transfer Mode is a cell switching network standard with a bandwidth from 25Mbit/s to 622Mbit/s.
Broadband access	Always-on internet access (at a speed of at least 256Kbit/s)
Broadband content	Digital content (Music, Movies, Games, etc.) delivered over Broadband networks, for which the end-customer is billed by the Broadband access provider.
Broadband penetration	Percentage of households that have at least one Broadband subscription to any of Broadband access technologies (DSL, Cable, etc.).
Broadband services	Services delivered and billed for by Broadband access providers (e.g. virus protection, spam filter, parents control etc.).
Cable, HFC	Hybrid Fibre Coaxial is a Broadband access technology using a combination of fibre trunks and then coaxial TV cable for transmitting high-bandwidth data and video programming to customers' residences.
Cable MSO	Cable Multi Service Operator, Cable TV operator, moving towards Triple Play
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CDMA, CDMA2000	Code-Division Multiple Access is a digital cellular technology, allowing many users to occupy the same time and frequency allocations in a given band/space.
Churn	Percentage of customers cancelling their subscription and disconnecting from a particular Broadband service provider.
Devices, CPE	Customer Premises Equipment are Broadband-enabled equipments for end-users, e.g. modem, router, VoIP handset or other equipment located at customer premises.

DOCSICS	Data Over Cable Service Interface Specification is an international standard developed by Cable Labs which defines the communications and operation support interface requirements for a data over cable system.
DRM	Digital Rights Management
DSL	Digital Subscriber Line is a technology for high-bandwidth data delivery over ordinary copper telephone lines.
DSLAM	Digital Subscriber Line Access Multiplexer; a mechanism at a phone company's central location that links many customer DSL connections to a single high-speed ATM line.
DVB-T/H	Digital Video Broadcasting – Terrestrial/Handheld
ETTH	Ethernet To The Home is a specific application of Fibre to the premises (FTTP). Where FTTP and Fibre To The Home (FTTH) are focused upon the physical delivery medium of "fibre" optic cables, ETTH envisioned a more generalized solution for evolving the carrier networks from a circuit switched model to an entirely packet switched model using Ethernet as opposed to ATM and other competing standards.
EuroDOCSIS	Data Over Cable Service Interface Specification (DOCSIS) is an international standard developed by Cable Labs which defines the communications and operation support interface requirements for a data over cable system. The first EuroDOCSIS specification was version 1.0, issued in March of 1997, with revision 1.1 following in April of 1999. Owing to increased demand for symmetric, real-time services such as IP telephony, EuroDOCSIS was again revised to enhance upstream transmission speeds and Quality of Service capabilities; this revision – EuroDOCSIS 2.0 – was released in January 2002. EuroDOCSIS 3.0 will be standardized by the end of 2006.
EV-DO, 1XEV-DO	Stands for "EVolution-Data-Only", which is a "3G" standard and part of the cdma2000 family that addresses only data, not voice and offers very high data rates (up to 2.4Mbit/s).
FBWA	Fixed Broadband Wireless Access
FCC	Federal Communications Commission
FMC	Fixed/Mobile Convergence
FTTB	Fibre To The Building
FTTC	Fibre To The Curb refers to a telecommunications system based on fibre-optic cables run to a platform that serves several customers; each of these customers has a connection to this platform via coaxial cable or twisted pair.
FTTH	Fibre To The Home is a Broadband access technology, capable of delivering exceptionally high data-transfer speeds.
FTTN	Fibre To The Node is a Broadband architecture that provides high speed internet and other services to the home by running fibre to the node and VDSL over the existing telephone copper plant to the home. This architecture costs less to deploy than the competing FTTP technology but does not bring the full

	bandwidth capability of the fibre to the home in turn (data rates are limited to 25-30Mbit/s).
GB	Gigabyte
GSM	Global System for Mobile Communications is the most popular standard for mobile phones in the world. GSM service is used by over 1.8 billion people across more than 210 countries and territories. The ubiquity of the GSM standard makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world.
HDTV	High-Definition television means broadcast of television signals with a higher resolution than traditional formats (NTSC, SECAM, PAL) allow. Except for early analogue formats in Europe and Japan, HDTV is broadcasted digitally, that why its introduction sometimes coincides with the introduction of digital television (DTV).
HFC	Hybrid Fiber Coaxial (HFC) is a telecommunications industry term for a network which incorporates both optical fibre along with coaxial cable to create a Broadband network. It has been commonly employed by cable TV operators since the 1990s.
HSDPA	High Speed Downlink Packet Access is a mobile telephony protocol, also called 3.5G (or "3½G") and representing a variation of 3G; it doubles network capacity and increases download data speeds five-fold.
HSPA	High Speed Packet Access
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronic Engineers (IEEE) sets standards for networking, in particular the 802 standards.
IM	Instant Messaging
IP	Internet Protocol
IPTV	Internet Protocol Television
IPv6	Internet Protocol version 6 is a network layer standard used by electronic devices to exchange data across a packet-switched network. It follows IPv4 as the second version of the internet Protocol to be formally adopted for general use.
ISP	Internet Service Providers, provisions Broadband access to its customers, often resells it from NSPs.
Kbit/s, Mbit/s	Kilobits per second, Megabits per second
KDGS	Also known as "Power 93.9", KDGS is a rhythmic contemporary hits outlet serving the Wichita, Kansas market. The station is licensed to Andover, Kansas, is owned by Entercom and broadcasts at 93.9 MHz with an ERP of 25kW.
LLU	Local Loop Unbundling refers to the process of allowing telecommunications operators to use the twisted-pair telephone connections from the telephone exchange's central office to the

	customer premises. This local loop is owned by the incumbent local exchange carrier (ILEC).
LTE	Long Term Evolution
MBWA, Mobile Broadband	Mobile Broadband Wireless Access systems enable delivery of data at speeds ranging from 384Kbit/s to 4Mbit/s, with customers free to move over wide areas.
MIMO	Multiple-input multiple-output communications refers to the communication using dual-array multiple-antenna systems in electrical engineering.
MoU	Minutes of Use
MPEG	Moving Picture Experts Group
MPEG-4	Expands MPEG-1 to support video/audio "objects", 3D content, low bitrate encoding and support for Digital Rights Management. Several new (newer than MPEG-2 Video) higher efficiency video standards are included (an alternative to MPEG-2 Video), notably, Advanced Simple Profile and Advanced Video Coding.
MPLS	Multiprotocol Label Switching
NGN	Next Generation Network
NRA	National Regulatory Authorities
NSP	A Network Service Provider (NSP) owns and operates the network and provisions Broadband access to its customers.
P2P	Peer-to-Peer technology (e.g. KaZaA, Gnutella, Overnet networks, etc.)PCMCIA Personal Computer Memory Card International Association are new PC cards.
PDA	Personal Digital Assistant
PPP	Public Private Partnerships
PPV	Pay-per-view
PSTN	Public Switched Telephone Network
PWLAN	Public Wireless Local Area Network, hotspot
QAM	A modulation scheme which conveys data by changing (*modulating*) the amplitude of two carrier waves. These two waves (usually sinusoids) are out of phase with each other by 90° and are thus called quadrate carriers – hence the name of the scheme.
QoS	Quality of Service
ROI	Return on Investment
R&D	Research & Development
Satellite Broadband	Broadband access via a satellite
SDH	Synchronous Digital Hierarchy
SDTV	Streaming and on-demand services

TDD	Time division duplex, the application to separate outward and return signals
Telco	Telecommunications Company (traditional telephone operator)
TIME	Telecommunications, IT, Media & Electronics
Triple Play	Triple Play service is a marketing term for the provisioning of the three services; high-speed internet, television (Video on Demand or regular broadcasts) and telephone service over a single Broadband connection. Triple Play focuses on a combined business model rather than on solving technical issues or a common standard.
TV	Television
ULL	Unbundling of Local Loop
UMTS	Universal Mobile Telecommunications System is one of the third-generation (3G) mobile phone technologies; it uses W-CDMA as the underlying standard, is standardised by the 3GPP and represents the European/Japanese answer to the ITU IMT-2000 requirements for 3G Cellular radio systems.
USB	Universal Serial Bus
USP	Unique selling proposition
VAS	Value Added Services
VDSL	Very high bit-rate DSL and capable of transferring up to 52 Mbit/s down-stream and 16Mbit/s upstream.
VoD	Video on Demand
VoIP	Voice over internet Protocol
WiMax	Worldwide Interoperability for Microwave Access
WLAN, WiFi	Wireless Local Area Network, Broadband access technology using unlicensed frequency spectrum
Web 1.0	First generation of services available on the World Wide Web
Web 2.0	Web 2.0 generally refers to a second generation of services available on the World Wide Web that lets people collaborate and share information online.
xDSL	xDSL refers to different variations of DSL, such as ADSL, SDSL or VDSL

Appendix C About Arthur D. Little

Arthur D. Little's Telecommunications, IT, Media & Electronics (TIME) Practice is a global network of world-class professionals. Together we offer an unparalleled combination of industry experience, understanding of the underlying technologies shaping the global digital industries and mastery of the business processes within these industries. Our work for companies across the value chain in TIME has two main thrusts:

- We help our clients "lead the pack" – and ultimately increase their value – by revolutionizing their strategies and differentiating their products and services globally.
- We also help our clients enhance their performance and grow their profits by propagating best practices throughout their organizations.

We guide our TIME clients towards a deeper understanding of the strategic, operational and cultural determinants of technology, innovation and financial management, as well as transferring the skills to manage these determinants for the optimal benefit of all their stakeholders.

About Arthur D. Little

Arthur D. Little is the world's first management consulting firm, founded in 1886 in Cambridge, Massachusetts, USA. We are leading-edge innovators, combining industry knowledge, functional experience and technology skills to help our clients grow and create extraordinary value. We have spent 120 years renewing and reinventing ourselves continuously – we come to our clients with a fund of fresh knowledge and experience in leading industries around the globe. Arthur D. Little people bring curiosity, creativity, integrity and analytical rigor to every job, which means fast and dramatic performance improvements. Together with our partners Altran Technologies and Cambridge Consultants Ltd we have 16.000 professionals at your disposal in more than 30 offices worldwide.

Appendix D **Contacts**

Authors of the Report

Konstantinos Apostolatos
Director Benelux
+31 10 2018 817
apostolatos.konstantinos@adlittle.com

Karim Taga
Managing Director Austria
+43 1 515 41 43
taga.karim@adlittle.com

Patrick Suter
Project Manager
+41 44 722 89 15
suter.patrick@adlittle.com

TIME Practice Leaders in your region are:

Austria	Karim Taga	taga.karim@adlittle.com
ASEAN	Thomas Kuruvilla	kuruvilla.thomas@adlittle.com
Belgium	Jean Fisch	fisch.j@adlittle.com
Brazil	Celso Gonzalez	gonzalez.celso@adlittle.com
France	Ignacio Garcia-Alves	garciaalves.ignacio@adlittle.com
	Eric Hazan	hazan.eric@adlittle.com
Germany	Arno Wilfert	wilfert.a@adlittle.com
Greater China	GuangHai Li	li.guanghai@adlittle.com
Italy	Giancarlo Agresti	agresti.giancarlo@adlittle.com
Japan	Yoshikazu Matsuoka	matsuoka.yoshikazu@adlittle.com
Korea	Sungtae Jun	jun.sungtae@adlittle.com
Netherlands	Konstantinos Apostolatos	apostolatos.konstantinos@adlittle.com
Portugal	Grant Greatrex	greatrex.grant@adlittle.com
Scandinavia	Bo Lenerius	lenerius.b@adlittle.com
Spain	Eulogio Naz	naz.eulogio@adlittle.com
	Jesus Portal	portal.jesus@adlittle.com
Switzerland	Reine Wasner	wasner.reine@adlittle.com
UK	Trevor Brignall	brignall.trevor@adlittle.com
	Michael Natusch	natusch.michael@adlittle.com
USA	Martyn Roetter	martyn.roetter@adlittle.com
Venezuela / Colombia	Adriana Acevedo	acevedo.adriana@adlittle.com

The authors wish to acknowledge the critical contributions to this report made by Bertram Boelinger (Germany), Etienne Brumauld des Holieres (France), Sascha Frommhund (Austria), Morgane Gaubier (UK), Beat Hangartner (Switzerland), Bernhard Nagiller (Austria), Martyn Roetter (USA), Markus Schroeter (Switzerland), Ashish Sharma (Singapore/USA), Nina Stanek (Switzerland), Jens Wagner (Switzerland) and many more around the world.

Arthur D Little