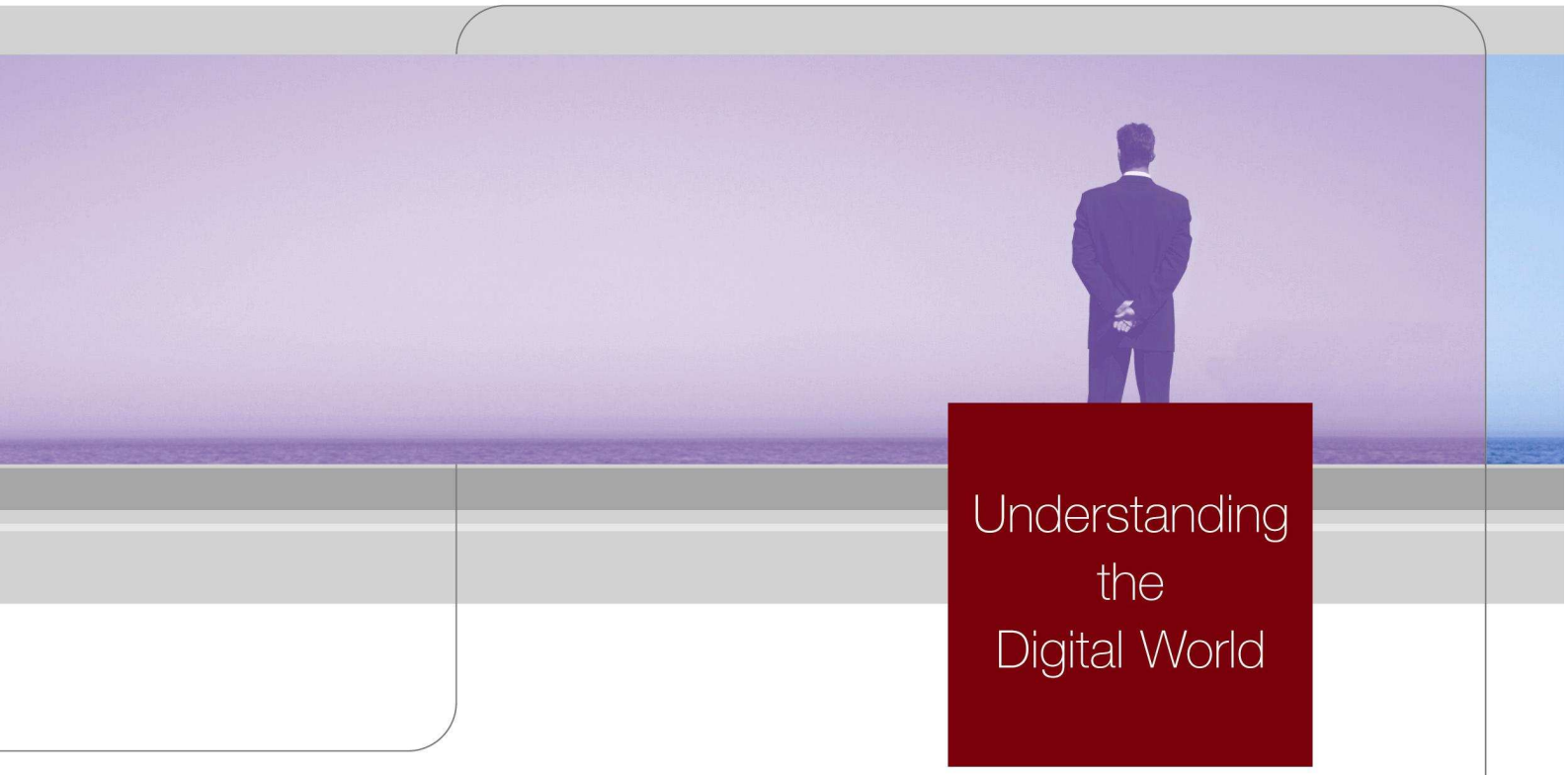

Understanding the Digital World

The market's evolution to very high-speed

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Executive summary

After more than a decade of trials and experiments, fibre on the access network is becoming a reality. Market leaders like Japan and the United States will probably count in the early beginning of 2007 respectively 6 and 1 million FTTx[1] subscribers for different reasons explained in this paper. Meanwhile in Europe, several of the larger incumbent telcos are now deploying, or making plans to deploy, FTTN + VDSL solutions. The growing ubiquity of ADSL has helped educate the global market in online applications but, as this paper will reveal, developing new consumer applications and video services will soon require more bandwidth than ADSL can provide. Even if mature FTTx technologies are now available, industry players and public authorities will have to devise effective solutions to overcome the barriers and hurdles currently hampering the development of FTTx markets.

In this paper, we will begin by describing FTTx commercial achievements around the globe, then endeavour to demonstrate how although ADSL has been a driving force in enabling the deployment of FTTx, it is now coming up against its limitations. We will examine currently available very high-speed access technologies, and identify the barriers and challenges that FTTx will need to overcome to spur the market's momentum. And, finally, we will describe several possible growth scenarios which will lead to residential coverage rates of between 20% and 80% by 2015 – based on several criteria, and depending on the state of each national market.

[1] FTTx stands here for Fiber To The Home of Fiber To The Building or Fiber To The Node.

Commercial FTTx entering a major growth stage

As of mid-2006, the very high-speed access market had become a reality, particularly in Asia and the United States.

Table 1: Number of FTTx Subscribers at the end of 2005

(in thousands)

Japan	South Korea	N. America	Sweden	Italy
4,640	1,620	500	321	257

Source: IDATE

Asia is clearly the leader in the area of very high-speeds deployments, with large scale deployments having been rolled out by Japanese and Korean incumbents, and more recently by alternative operators and power utilities in Japan. NTT pushed fibre optic cable deep into its network early on, with its two regional subsidiaries providing FTTH access based primarily on PON technologies (GEPON now being deployed). Incumbent telco KT and other Korean operators rely chiefly on bringing fibre optic cable to the basement of buildings, then extended by LAN (Ethernet) or VDSL. Japan and South Korea's stature as pioneers can be explained by the support of public authorities, along with certain particular characteristics such as high population density in the large metropolitan areas of Tokyo and Seoul, and the prominence of high-rise buildings and aerial connections, all of which make for cost-effective FTTx projects. On the other hand, there appear to be no specific services actually driving this lead, with the possible exception of the hugely popular online gaming in South Korea. Furthermore, strict copyright restrictions have limited the possibilities of offering TV programmes on high and very high-speed networks in both countries (only around 100,000 IPTV subscribers in Japan as of mid-2006). Nevertheless, the situation is changing and, in July 2004, NTT launched an IPTV platform (4th Media) providing VoD content, karaoke titles and IPTV channels via affiliate ISPs. One of the chief advantages reported by FTTH providers in Japan is lower churn out than with its ADSL subscribers – an asset that will put them in a stronger position when negotiating rights with content providers and TV broadcasters (stable subscriber base and the ability to distribute HD content). In April 2006, Japan was home to 5,642,000 FTTx subscribers[2], representing 24.1% of the total broadband subscriber base (vs. 14.3% for cable and 61.6% for ADSL).

In the **United States**, FTTH deployments were initially confined to trials in a few municipalities. But, over the last two years, RBOCs Verizon and AT&T (ex-SBC) have been stepping up their investments. Out-distanced in the broadband access market by cable modem operators, and handicapped compared to European telcos by long copper loops, Verizon and AT&T are banking on the deployment of their new infrastructures to increase their market share and allow them to roll out services like HDTV. Their projects are benefiting from recent decisions from the courts and the FCC, absolving them of having to share the optical infrastructure with third parties. In most parts of the country, they are nonetheless facing one sizeable obstacle, namely the obligation to negotiate franchise rights with each municipality. Worth noting is that Verizon (FiOS) originally opted for BPON FTTH technology, but will likely begin deploying GPON technology instead in late 2006 (chiefly because of BPON's limited bandwidth issues). It was estimated that, in the first quarter of 2006, there were roughly 400,000 FiOS subscribers out of the nearly 3.6 million homes passed. At the end of 2006, Verizon's base could reach 900,000 subscribers, for 6 million homes passed. AT&T (Project Lightspeed), in the meantime, relies on FTTN solutions (for 17 million homes) based on ADSL2+ or VDSL, except in greenfield areas (1 million FTTH households).

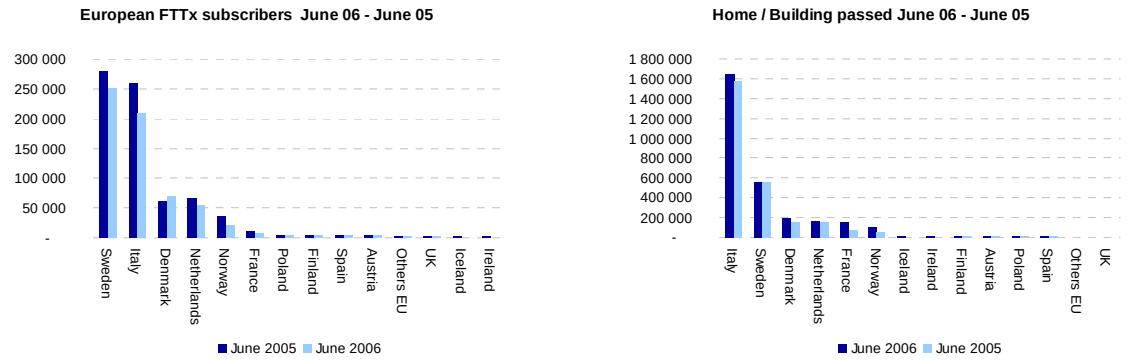
The situation in **Europe** differs somewhat, and is still in the early stages: pioneering countries, such as Sweden and Italy, owe their advance to initiatives by private operators B2 (now owned by Telenor) and FastWeb, respectively. It is nonetheless worth noting that, in recent months, these operators have been tending to return to ADSL2+ and to unbundled telephone lines to extend their customer base, rather than expanding their optical networks. Elsewhere, the rare very high-speed access network deployments are often due to the involvement of power utilities or local authorities (Denmark, the Netherlands) which are installing neutral infrastructures open to all third-party providers ("open

[2] Around 60% being FTTH subscribers, the remaining 40% being FTTB.

access"). It is only recently that incumbents have become involved in fibre optic access networks. Deutsche Telekom was the first to announce a large scale plan (3 billion EUR investment with the goal of deploying a very high-speed access infrastructure based on FTTN + VDSL2 in 10 cities by the end of 2006, and 90% of households in 50 cities by the end of 2007). This project is, however, creating conflicts with Brussels which, running contrary to an agreement negotiated with German authorities, requires that DT make its infrastructures available to third parties. Along with Deutsche Telekom, Swisscom was due to launch commercial VDSL2 services in summer 2006, and plans on having half of all Swiss households covered by its VDSL network by 2007. KPN and Belgacom have also chosen FTTN + VDSL solutions to deliver very high-speed access to the Internet, while France Telecom began testing a pure FTTH solution (based on GPON) in Paris and the surrounding area (several thousand subscribers) in June 2006.

We estimate that, as of mid-2006, there were 2.7 million homes passed for very high-speed access in Europe[3], and around 820,000 FTTx subscribers.

Figure 1: Number of FTTx subscribers and homes passed in Europe (June 2006-June 2005)



Source: IDATE

Table 2: Major recent FTTx deployments in Europe

Countries	Players		Home/Building passed (end 2006)
Denmark	EnergiMidt	Power utility	40 000
Finland	Verkko-osuuskunta Kuuskaista	Municipalities	2 500
France	CiteFibre	Alternative operator	10 000
	Erenis	Alternative operator	85 000
Iceland	Reykjavik Energy	Power utility	17 000
Ireland	Magnet Networks	Alternative operator	8 000
	Smart Network	Alternative operator	5 000
Austria	Vienna	Municipalities	50 000
Germany	Deutsche Telekom	Incumbent/VDSL	10 major cities i.e 2.9 M Homes
Switzerland (end 2007)	Swisscom	Incumbent/VDSL	50% of Swiss Households
Belgium	Belgacom	Incumbent/VDSL	n.a.
Netherlands	KPN	Incumbent/VDSL	n.a.

n.a.: non available

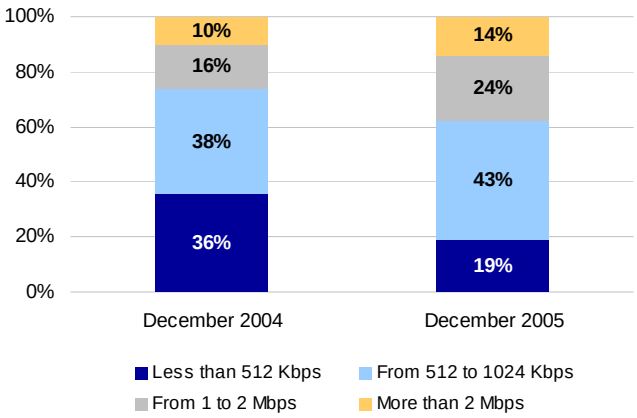
Source: IDATE

[3] EU 15 + Norway, Iceland, Poland and Switzerland.

Copper infrastructure: spurring very high-speed, but within limits

The success of broadband access around the world (around 210 million subscribers at the end of 2005) can be considered a driver for FTTx deployments, having contributed to educating the market. The bandwidth offered by DSL or cable modem technologies has increased considerably over the last five years, typically ranging between 512 kbps to 20 Mbps at present (ADSL2+, FTTLA[4]). Furthermore, the success of triple play bundles over DSL in countries such as France (more than 5.5 million homes equipped with a triple play CPE in June 2006) is bringing consumers a new form of application consumption: **simultaneity**.

Figure 2: Growth of DSL download speeds in Europe



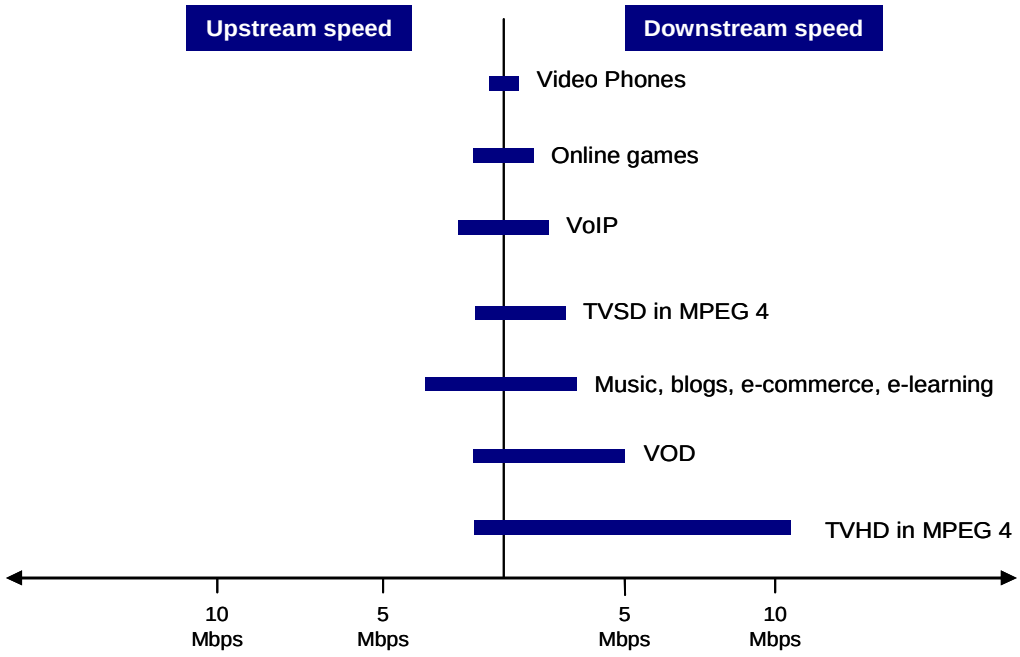
Source: IDATE

If ADSL technologies contributed to educating the market, they are nevertheless coming up against certain limitations, particularly their asymmetry and eligibility constraints. Beyond 1.5 to 2 km from the DSLAM (depending on the quality of the copper network) download speeds drops dramatically, and the minimum 10 Mbps needed for a triple play offer (based on SDTV) are no longer available to subscribers. For example in France where ADSL2+ was widespread, it is assumed that one line out of two will not get 10 Mbps in speed required for a triple play offering (and even in Paris, one line in 5 will not be eligible for 10 Mbps).

These two major constraints inherent in ADSL technologies, i.e. **asymmetry** and **bandwidth limitation**, prevent operators from being able to supply the applications that digital homes will be demanding in the not too distant future.

[4] Europe including the 15 + Iceland + Norway

Figure 3: Bandwidth currently required by type of application



Source: IDATE

At first glance, no residential application on its own seems to truly justify a current need for bandwidth greater than 20 Mbps (theoretical downstream rate supplied by ADSL2+, very close to the local exchange). Nevertheless, the emergence of HDTV could pose a real problem, even with the upcoming implementation of MPEG-4 compression techniques that reduce the bandwidth required (6 to 8 Mbps required per HD channel by 2007-2008 versus 1 to 3 Mbps for an SDTV channel). The prospect of offering two or three HD channels simultaneously clearly requires guaranteed bandwidth which is beyond ADSL2+'s capabilities. Other specific services such as VOD, P2P, enhanced instant messaging, video-blogs, online gaming…., which are becoming increasingly popular in the Web2.0 era, could have an impact on upstream speeds. Elsewhere, without being able to identify specific applications for which an FTTH network must be deployed, we still need to take overlapping usage into consideration (several online service users in the same home), coupled with increasing applications supported by the operator's "Home Gateway" and the proliferation of multimedia equipment (HD digital cameras, high definition televisions, DVR, webcam, MP3 players…), all of which will generate significant upstream traffic.

VDSL2, EPON, GPON, Ethernet: FTTx technologies ready for deployment

First, it is important to distinguish between FTTN (Fibre To The Node) solutions and FTTH (Fibre To The Home) options.

FTTN deploys fibre optic cable all the way to an intermediate node located between the operator's central office and the user's terminal. Last mile connection termination is generally supplied by the phone line's copper infrastructure and xDSL equipment, particularly with VDSL2. This type of configuration delivers very high speeds, but still depends on how close the node is to the user's building (up to 100 Mbps at less than 300 metres from the distribution node for VDSL2). When the intermediate node is a street cabinet, problems of coexistence can occur (signal disruption) with ADSL equipment installed by other operators, and lead to complex scenarios if the VDSL is unbundled. Also, FTTN+VDSL architectures remain asymmetrical.

VDSL2 has begun to be deployed, with one of the largest scale roll-outs, as already mentioned, being undertaken by Deutsche Telekom in Germany. VDSL2 technology was standardised by the ITU on 27 May 2005, under the name G.993.2.

As to FTTH, it is a solution that uses fibre optic cable from end to end between the central office and the user's premises. FTTH networks can be deployed using two distinct configurations: point-to-multipoint (fibre optic cable not dedicated to users but shared upstream of an intermediate node) or point-to-point (where each user has dedicated fibre optic cable from end to end). Concerning point-to-multipoint configurations, a distinction needs to be made between passive, or PON (for Passive Optical Network), and active networks such as double star Ethernet.

Table 3: Passive Optical Network (PON) Standards

Name	Organisation	Date Adopted	Characteristics
BPON	ITU	February 2001	ATM Transport Protocol Maximum speeds: 1.2 Gbps downstream, 622 Mbps upstream Up to 32 users per tree
GPON	ITU	End of 2005	Transport Protocols: ATM, Ethernet, TDM Maximum speeds: 2.4 Gbps downstream, 1.5 Gbps upstream Up to 64 users per tree
EPON	IEEE	Mid-2004	Transport Protocol: Ethernet Maximum rates: 1.25 Gbps symmetrical (GEPON) Up to 32 users per tree

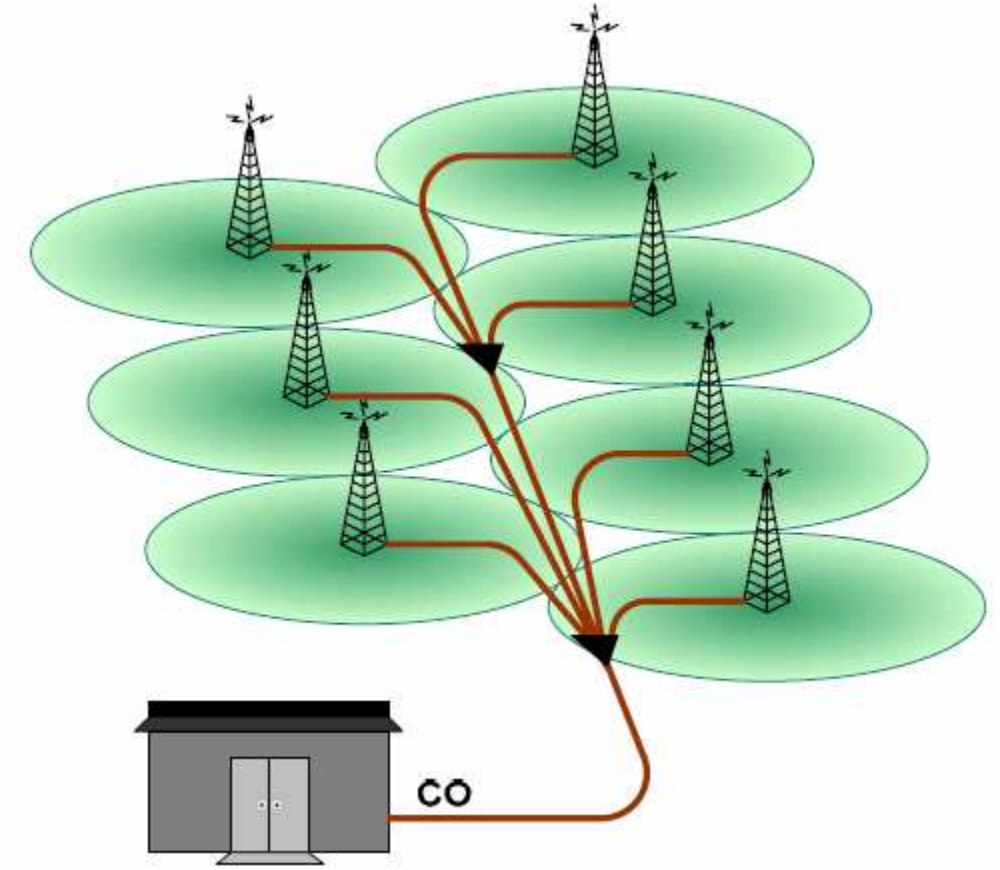
Source: IDATE

Point-to-point networks are generally based on Ethernet technology. PONs include several international standards (APON, BPON, EPON, and GPON), each one having specific attributes, particularly in terms of performance. Adopted in late 2005, GPON can reaches now speeds of 2.4 Gbps downstream and 1.5 Gbps upstream, in addition to being multi-protocol, which means that it supports ATM or IP as well as Ethernet, and can manage up to 64 users per tree (compared to 32 for other PON standards). GPON as well as EPON, meanwhile, have the advantage of delivering symmetrical speeds (1.25 or 1.5 Gbps).

Even if interoperability is not yet complete, Ethernet as well as EPON and GPON technologies can be considered mature – as proven by current deployments – and new standards enabling greater bandwidth will be defined in the coming years: 10GEPON and 10GPON, or even WDM-PON which is being promoted by ETRI (Korea) in particular.

For rural areas, other technologies could also be used in future, and particularly forthcoming radio technologies (BWA at 20 or 40 GHz, 4G, or the 802.11n standard). Also possible for providing very high-speed access to sparsely populated areas are hybrid architectures that combine a PON distribution network and radio base stations for delivering final access.

Figure 4: PON/radio base stations hybrid architecture



Source: IEEE

Identified barriers and hurdles for FTTH

In 2006, IDATE developed a cost model to estimate the total investment required to cover 40% of the French population (10 main cities and suburbs) with FTTH technologies (GPON and Ethernet point-to-point). The overriding conclusion of this exercise was that, regardless of the technology chosen, **civil engineering** will account for 70% of deployment costs. In Europe, we have witnessed several examples of how private operators have managed to avoid costly civil engineering works by using existing passive infrastructures (Milan and Paris sewer systems) to roll out fibre as close as possible to the buildings. Another solution for circumventing these costs would be to adopt nationwide urban planning laws which require greater sharing of existing or new buried ducts (especially in Europe where there are no longer aerial deployments in urban areas).

Another hurdle when deploying fibre to the home or even fibre to the MDU is gaining **access to the building**. Clearly, the current case by case approach (i.e. negotiating installations one by one) is not cost-effective for operators. As a result, a single solution needs to be found, if not at the national level, at least in each municipality (reviewing urban planning laws and/or creating a system of "Building Certification").

On the application side of things, as mentioned earlier the chief driving forces behind FTTx deployment will be **video services** and especially HD content. The future relationship between all of the value chain's players – telcos, TV broadcasters and the top internet companies – is far from being set in stone. In Europe, for instance, despite the success of IPTV in certain countries (France), the arrival of HDTV will require that the relationship between content providers and telcos be clarified, as telcos are beginning to offer VoD content directly, and negotiating sporting rights (e.g. football matches) for themselves. The ongoing net neutrality debate continues to make headlines in the US, with new FTTH players (RBOCs) fighting to prevent online heavyweights like Google, Yahoo! and Microsoft from monopolising the value generated by new services enabled by FTTx connections.

And, finally, clarification will also be needed on the **regulatory** side of things. In Europe, fierce debates have been triggered by the Deutsche Telecom initiative, and by the ongoing Review of the EU's current regulatory framework. This framework includes regulations that date back to December 2000, which require unbundling of the local copper loop if only a portion of this loop is used, so FTTN/VDSL solutions (Deutsche Telecom) fall into the existing framework's definition, even when taking into account the cost of innovative risk-taking. As a result, other incumbents like France Telecom are choosing to wait before undertaking wide-scale trials with a new infrastructure, and opting instead for fibre optic cable to the subscriber. If an infrastructure is completely new, the regulation of December 2000 no longer applies. It nevertheless remains that services supported by this new infrastructure, as well as the prices charged, will likely differentiate themselves significantly from the services delivered by ADSL, in cases where the broadband operator enjoys significant market power. But the operator's investment could fall under the emerging market category, and so not be subject to ex ante regulation, requiring cost-oriented tariffs. As it stands, however, there is nothing to indicate that the changes being made by the Review to the current regulatory framework will give European telcos greater flexibility, although a clearer regulatory stance on the issues will help steer the various players' future decisions regarding FTTx deployments.

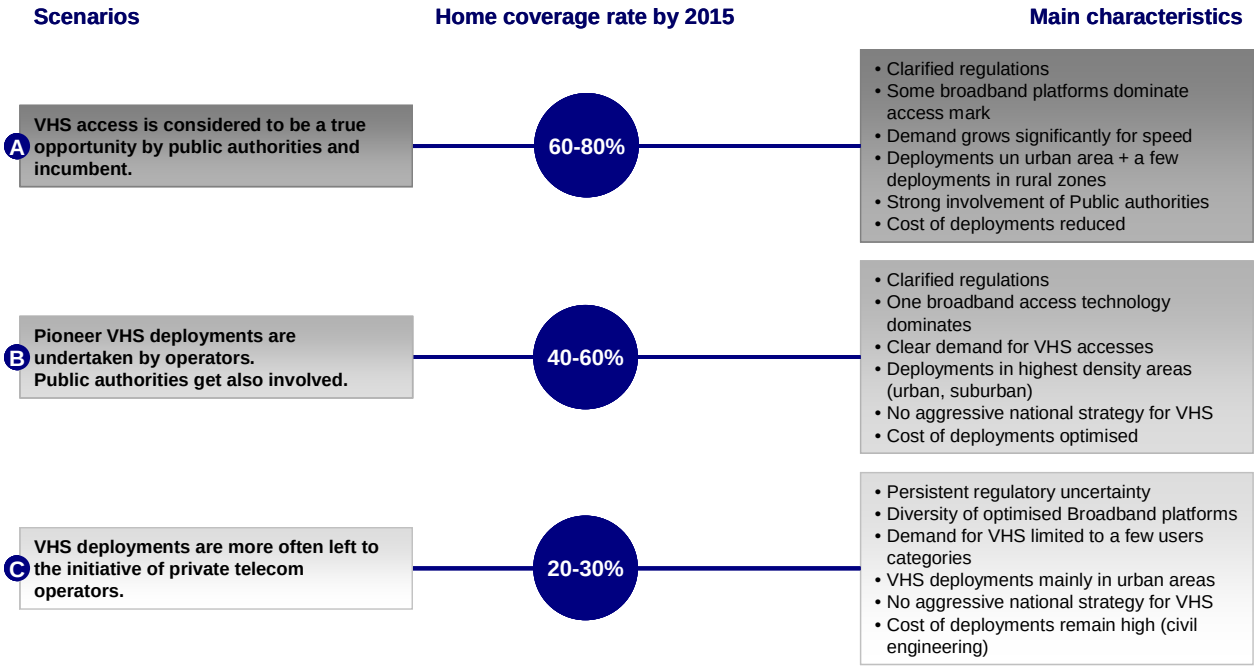
Three FTTH deployment scenarios, up to 2015

The costs involved in deploying FTTH constitute the first obstacle to the development of very high-speed access. But, as indicated earlier, other criteria too need to be taken into account: growth of the broadband market and of associated services such as HDTV, the regulatory situation, the degree of competition between platforms (USA, Benelux), structural factors such as population density, the involvement of public authorities in general, and of local bodies in particular…. The way that each of these criteria evolves will have an impact on the various players' deployment strategies.

We have thus established three different scenarios that take account of the varying impact of key deployment factors, and so creating a more or less favourable environment for the development of very high-speed access:

- In the **first scenario**, very high-speed access is considered a necessity by the large incumbent operators, all rolling out their first deployments before 2010 – targeting widespread coverage. Their investment will be completed by the involvement of public authorities seeking to maximise the network's footprint nationwide. Under this scenario, a **high home coverage rate** is expected in developed markets in the order of **60% to 80% by 2015** (a scenario that could result in Japan, South Korea, Sweden and the Netherlands).
- In the **second scenario**, pioneer deployments are undertaken on the initiative of both incumbents and alternative operators seeking a competitive advantage. No national strategy is in place when deployments begin. At the same time, some local authorities have created PPP partnerships in view of building an open access very high-speed infrastructure. Under this scenario, a **home coverage rate** is expected in developed markets in the order of **40% to 60% by 2015** (USA, Denmark, Italy, France and Germany could emulate this scenario).
- Finally, in **the third scenario**, only a few private players are involved in very high-speed access, limiting deployment to areas with high market potential. As a result, coverage will vary widely from region to region. Incumbents confine themselves to trials or highly targeted deployments, while public authorities do not view very high-speed as a priority. Under this scenario, a **home coverage rate** is expected in developed markets in the order of **20% to 30% by 2015** (examples of this scenario could include the UK and Spain).

Figure 5: Very High Speed Access Development Scenarios



Source: IDATE

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