Broadband for all – How far we are?

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Abstract: - Broadband access is one of the most important issues for telecom equipment manufacturers, content and technology providers, cable and fixed or wireless operators. The paper presents overview and brief description of the available access technologies, their advantages and disadvantages, obstacles and inhibitors for their wider exploitation, taking into account technical limitations, socio-economic issues and telecommunications regulatory status. The paper also briefly presents the current situation of Broadband access in EU countries with some relevant statistics, also showing differences between "OMS" and NMS countries.

Key words: - Broadband access technologies, Digital Divide, xDSL, Cable, Wireless, Inhibitors

1 Introduction

In general broadband refers to telecommunication in which a wide band of frequencies is available to transmit information. Because a wide band of frequencies is available, information can be multiplexed and sent on many different frequencies or channels within the band concurrently, allowing more information to be transmitted in a given amount of time.

Why Broadband? Strategic goal for 2010 set by the European Commission at the Lisbon European Council is "to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion"[1]. Word most appropriate to answer the question is knowledge. Our society is now defined as the "Information Society", a society in which low-cost information and ICT are in general use, or as the "Knowledge (-based) society", to stress the fact that the most valuable asset is investment in intangible, human and social capital and that the key factors are knowledge and creativity[2]. We live in time where the knowledge has the biggest power and most probably it will continue to be so in the future. This is the idea which is standing behind the initiative of Broadband for All [3] (Initiative of European Commission). How to acquire, provide, distribute knowledge in the fastest and the most convenient way, and if possible also in the cheapest way? The initiative has started in the year 2003 and now it is in its second phase with many ongoing projects (BREAD, BROADWAN, OPERA, just to name few) dealing with the realisation of this initiative. How to achieve Broadband for all? BReATH and BREAD projects have for the goal to analyse current state on the field, to identify the limitations, obstacles and inhibitors for further development, and of course to provide roadmaps to overcome those obstacles. One of the main goals of the BReATH project is also to transfer the know-how and best practices from the technologically more developed EU countries to the New Member States, to bridge the gap which is present in many cases. The obstacles are not just of technical nature but also socio-economical and of course regulatory. Sect. 2 gives an overview of existing access technologies with a bit more accent on xDSL, cable, FTTx and Wireless access network technologies. Sect. 3 identifies the main inhibitors for BB development, taking into account technical, socio-economic issues, and as last but not the least telecommunications regulatory status.

2 Overview of some access technologies

Most present broadband access technologies in EU member states are xDSL technology variations (ADSL, ADSL2, ADSL2+, VDSL), followed by the cable access (cable modem, Hybrid Fibre Access). The main advantage of xDSL technologies is that the most of the infrastructure necessary for its functioning already exists – legacy of PSTN network owned by incumbent operators. ADSL on twisted pairs provides the most common method for providing broadband to locations within a few km of a local office. It has the potential to deliver 8 or more Mbit/s to many consumers living close to an exchange and therefore to support future services such as TV over IP. Cable networks grew partially as an initiative of the incumbent operators but as well as a result of, mostly smaller, private cable operators. Cable too is well suited for urban areas, and is very competitive with ADSL. Broadband by Power Supply Line (PLC) has the promise of low cost because it both exploits copper that is already deployed and offers high speed. But costs for cable and xDSL are already low due to the installed volumes so it will be tough for B-PLC to gain a market foothold. xDSL infrastructure is mostly owned by ex – incumbent operators, which as well presented/presents one of the biggest obstacles for wider Broadband use until EC's initiative to regulate telecommunication started to bring fruits – fair competition on the markets. Still this remains one of the issues, especially in some NMS countries which in average still significantly lag behind of most Old Member States (OMSs). Other bigger owners of the infrastructure are usually railway companies and the electric power suppliers companies. Wireless solutions for the access network appear to be the lowest cost solution for Green-field regions that have little copper or cable to date. WiFi lacks the bandwidth to scale up to the capacities needed for real time video services, but the new WiMax technology with WiFi will offer sufficient capacity to deliver typical commercial services, and it could support the leap forward in ICT capability needed in the future for small businesses and SMEs.

Figure 1 [4] is presenting number of Broadband users, both in New Members States (NMS) and OMS. From these figures it is clear that the NMS countries lag considerably behind the OMSs. The only exception is Greece (GR), which lags behind the other 14 OMSs even more than the NMSs of comparable size. Only Poland (PL), due to its size, has a non-negligible share of 1.5% of the total of 48.350.896 broadband lines implemented in the EU25 countries with all available technologies. EU15 countries have more than 95% (46.041.795 lines) share of broadband lines in EU25.

The penetration rate expressed by the number of broadband lines per 100 inhabitants gives better insight into the problem of the geographical "digital divide" since it takes into account the population of the countries (see Figure 2). From this point of view, the gap between the NMSs and the OMSs except Greece (and Ireland to some extent) is obvious. The only positive exceptions to this observation are Estonia and to some extent Slovenia. Average Broadband penetration rate in EU15 is 12%. In EU10 (NMS) is significantly smaller – 5,3%. Reasons for this could found in barriers identified in country survey performed by the BReATH consortium:

- Low availability of PCs
- Low computer literacy
- Affordability of a broadband connection
- Defensive pricing strategies or delaying tactics by the incumbent operator
- Delays in unbundling the local loop
- Available structural funding, but not actually being used
- Lack of Internet content in the national language.

The examples are taken from several countries and do not necessarily apply to a single country.

The benchmarking exercise performed by European Intelligence Unit shows the readiness of the countries to take advantage of broadband capability progress in regulation and strategic funding programmes relevant to broadband. The Economist Intelligence Unit (EIU) provides a valuable assessment of the state of readiness of 65 countries to take advantage of electronic services5. The EIU defines a country's "e-readiness" as a measure of its e-business environment. This provides a collection of factors that indicate how amenable its market is to Internet-based opportunities. To establish the rankings, the EIU uses a model developed in cooperation with the IBM Institute for Business Value, based on nearly 100 quantitative and qualitative criteria organized into six distinct categories. These six categories (and their weight in the model) are: connectivity and technology infrastructure (25%); business environment (20%); consumer and business adoption (20%); social and cultural environment (15%); legal and policy environment (15%); and supporting e-services (5%). From the NMS Estonia is ranked highest on the 26th place, immediately followed by Slovenia on the 27th place.

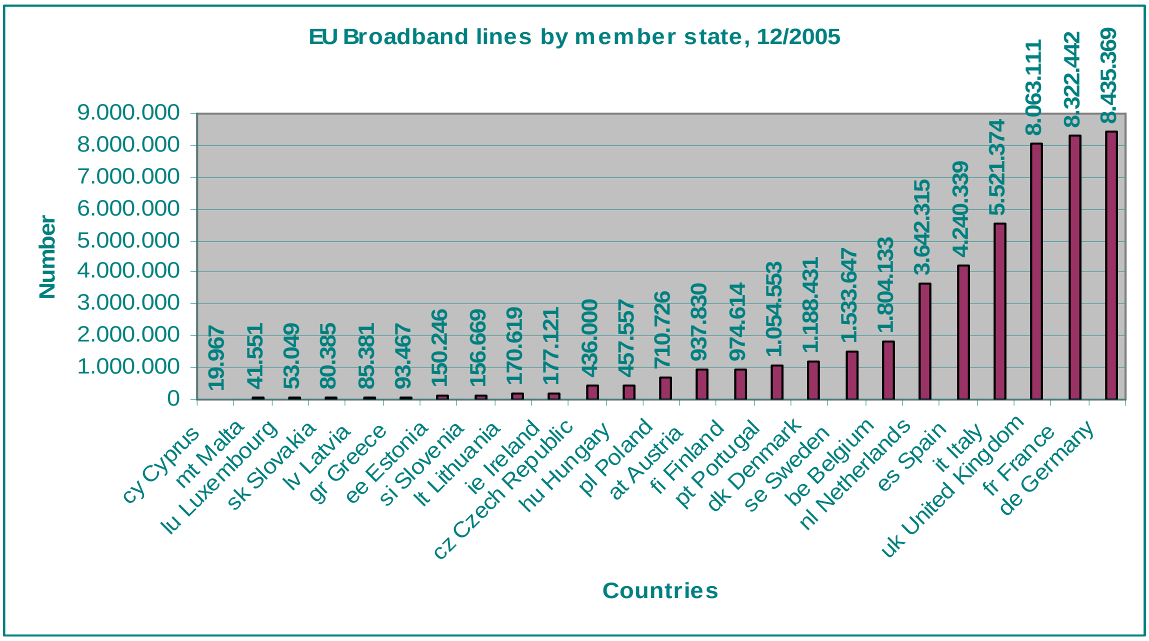

Fig. 1 Number of broadband lines in 25 EU member states as of December 2005

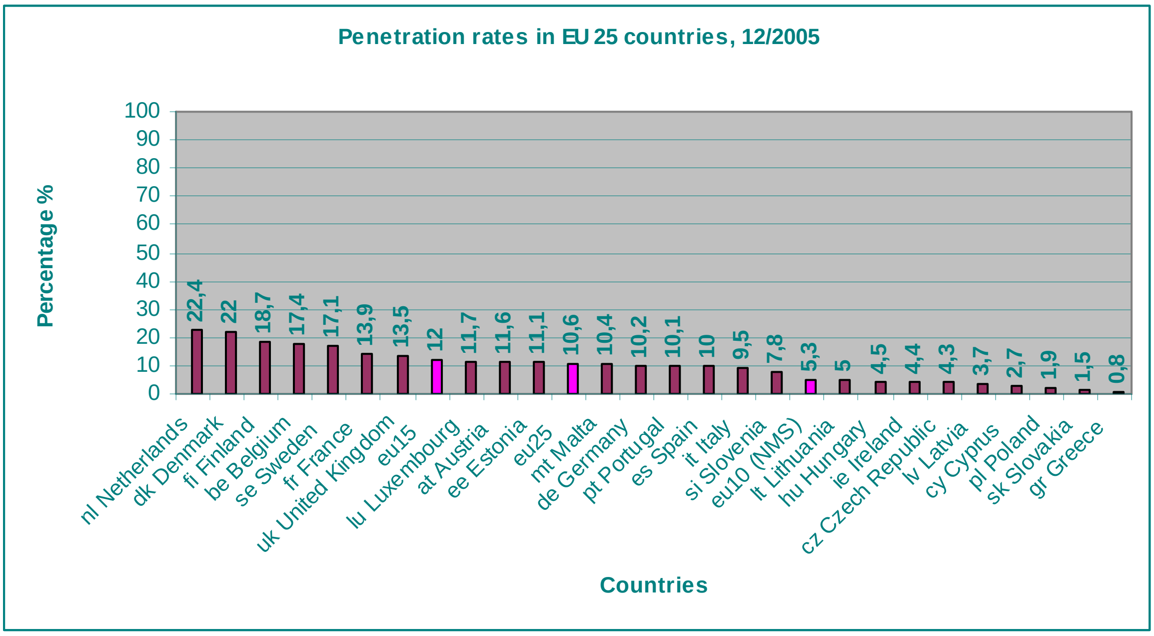

Fig. 2 Penetration rates in EU25 countries expressed by the number of broadband lines per 100 inhabitants as of December 2005

2.1 xDSL

Digital Subscriber Line (x stands for different variations, e.g. ADSL, ADSL2, VDSL) is an answer to increased demand for faster internet access, using more advanced technologies and allowing to further increase the speed. Figure 3 presents a typical xDSL access network.

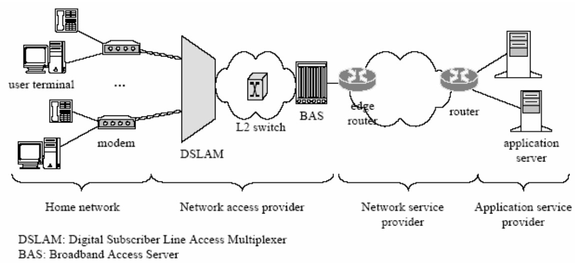

Fig. 3 A typical xDSL access network

Most used instance of DSL, ADSL, was developed in Bellcore laboratories (USA) in the end of 1980s. The advantage of xDSL is that it reuses the existing copper infrastructure. Another important advantage of xDSL is that almost every household is connected to the telephone network or better to say, many more then to e.g. Cable Television Network. Broadband DSL shows trend of growth over 100,000 of new users every day. By the end of 2005, global DSL subscribers approached 140 million, extending its share of the total broadband access market6. European Union countries accounted for close to 40% of the total growth in new broadband DSL subscribers in the period, confirming the EU's position as the number one most active DSL region worldwide. The UK and France led the way, each adding more than three million subscribers in 2005. xDSL allows simultaneous transmission of voice and data traffic. The frequency spectrum is divided in bands for voice, upload, and download traffic. Depending on xDSL flavour a different frequency band is used. ADSL is, due to its asymmetric nature, very suited for e.g. web browsing and other typical Internet applications where the downstream traffic is usually larger than the upstream traffic. Two improved versions of ADSL are ADSL2 and ADSL2+, first one providing increased speed and increased reach, and several technical issues that allow cost savings. ADSL2+ increases the bandwidth by extending the usable frequencies on the line. VDSL is the newest and the fastest DSL flavor allowing much higher speeds than other DSL technologies with disadvantage of its limited reach. This implies that the cable network has to be rolled out further into the access, and that VDSL is more suited for densely populated regions than rural areas. VDSL can already be seen as a hybrid fibre DSL solution for broadband access7. Figure 4 shows the differences between the various xDSL types.

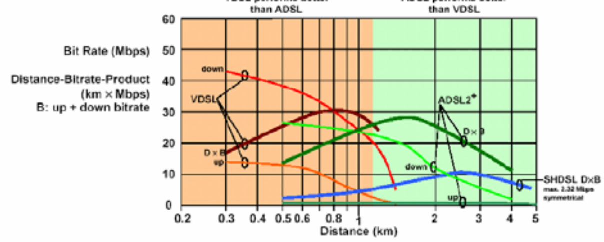

Fig. 4 Bandwidth versus reach of xDSL technologies [8]

2.2 Hybrid Fibre Coaxial Network (HFC)

In EU cable networks were deployed either by private or mixed private-public operators (e.g. in Belgium, Netherlands, Spain, some parts of France), or were owned (mostly partly) by the incumbents (Germany, Switzerland, Portugal, some parts of France). Exclusively for broadcasting HFC was used until 1995, and the development of broadband access was slower as compared to countries like USA and Canada for instance. For the following reasons:

- Public operators were not keen to promote a competitive technology on HFC as they had to sell the HFC networks
- Some complicated situations like in Germany where the networks are divided in different levels with different owners

Many small size operators, making broadband access and IP telephony difficult to develop

The evolution from broadcast to interactive broadband services is not trivial; it may require an expensive upgrade of the network. In NMS countries, for instance in Hungary, cable networks used to be of poor quality, and enabling their bidirectional use required a major overhaul. Though, in many cases such upgrades have been implemented.

Figure 5 summarizes the modern HFC. Although many variants can exist but in general the architecture includes several levels:

- A Main Head-end (Central Node) where all broadcast services are aggregated.
- The local nodes serve a number of coaxial areas via fiber links using usually analogue transmission. The boundary node between fiber and each coaxial area is called a Fiber Node.
- The coaxial area architecture can be either a star network with different levels, or more commonly a tree and branch network; this part becomes critical when very high bit rates have to be conveyed.

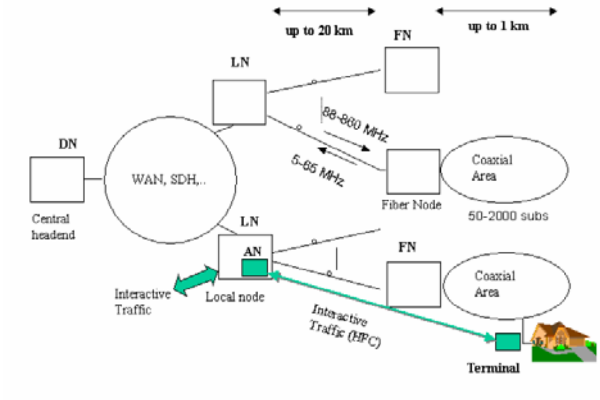

Fig. 5 Example of HFC architecture

The first priority issue is to offer more bandwidth per customers in a more efficient and cost effective way, and to integrate video services in the broadband offer. Issues to be tackled:

- Increase downstream capacity per subscriber, including both network capacity and terminal capacity
- Increase upstream network capacity, including more efficient use of the upstream
- Allow flexible sharing ratio between upstream and downstream traffic
- Load balancing between upstream and downstream capacity
- Evolve to a full IP architecture including video services, and supporting QoS, billing, security.
- Extend the framework to home network

Summarized, cable access provides an interesting alternative to xDSL since it offers the same range of capacity, and allows in addition to deliver multicast/broadcast services. At the same time it provides an interesting cost effective alternative to FTTH.

2.3 FTTx (Fibre to the x)

Access network based on optical fibre offers of all available technologies by far the highest speed and can support an unlimited set of services. FTTx would thus be a future-proof access solution. In Europe more than 95% of FTTx subscribers are concentrated in 4 countries: Sweden, Italy, The Netherlands and Denmark. The participation of incumbent operators in the deployment of FTTx is not very high in Europe. The roll out of a complete fibre network is still rather expensive and most of them do not see a profitable advantage in deploying such a network. The success in some European countries is mainly the consequence of a lot of government support (central government as well as municipalities). But also, in a lot of European countries (UK, France, Spain, Belgium), the FTTH deployment is very low or totally not available. Currently, the supporting technologies are concentrated into two categories, namely Fibre-to-the-Home (FttH) and Fibre-to-the-Curb (FttC). These categories are subdivided based on the types of optical components that are used in the last mile. These component types determine whether the network follows the Active Optical Network (AON) technology or the Passive Optical Network (PON) technology.

2.3.1 Active Optical Networks

Figure 6 shows one of the possible logical designs of AON for FttH. The fibre runs to the access point in the house, providing data link (layer 2 or L2) services. The traffic flows from the homes are aggregated by a neighborhood optical-electronic switch (e.g. in the street node). The traffic flows from the neighborhood nodes are aggregated in the district node by an optical-electronic switch as well. At this level, the aggregation may include (network) routing (layer 3). From here, traffic is routed towards the destined ISPs.

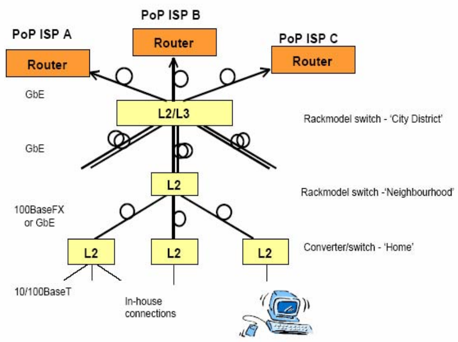

Fig. 6 Logical design of AON for FTTH

AONs contain an active electronic element (aggregation switch) between the traffic aggregator (district or neighbourhood) nodes and the customer premises equipment, which introduces extra costs but also advantages. By using switch technologies in every traffic aggregator, only the data destined for a particular customer are delivered to that customer.

2.3.2 Passive Optical Networks

PONs can support a variety of access network types such as FttH, FttC, FttB, FttU, FttEx or any other Fibre-to-the-X technology (see Figure 7). The term PON indicates that this technology is based on optical fibre and passive splitters. In most

PON implementations the downstream and upstream transmissions take place on the same fibre cable. In principle, the wavelengths used for the two directions could be the same. However, in practice different wavelengths are used for downstream and upstream, because then the separation of the two directions can be achieved using passive filtering, which results in improved performance and reduced costs.

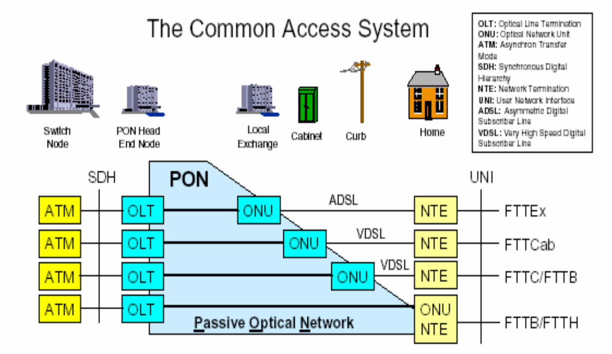

Fig. 7 PON [9]

2.4 Wireless broadband Internet access over 802.11 (WiFi) and 802.16 (WiMAX)

Large variety of wireless broadband access networks is available today. Although originally intended as a wireless option for LANs, now WiFi is sometimes used as access technology, in some cases even for outdoor users or for connecting to core cellular networks. Recently, one of the four bands of 802.11a has been specifically reserved for that purpose in the USA.

Table 4 shows two basic parameters of the wireless technologies for data transmission over the 802.11 and 802.16 networks, which is the theoretically achievable maximum transmission rate and range. In practice, transmission rates attainable in practice may be much lower than those shown in the table, as they are a function of the attenuation, which depends on the terrain and increases with distance. The actual transmission rate also depends on the type of antenna (outdoor or indoor) used at the user end, which is also a cost issue. Furthermore, the available bandwidth is usually shared between several customers.

Wireless technology for data transmission	**Theoretically achievable maximum transmission rate**	**Maximum range**
802.16d (2004 – WiMAX)	75 Mb/s	50 km
802.16e (Mobile WiMAX)	4 Mb/s	Up to 1 km
802.11b (WiFi)	11 Mb/s	100 m
802.11a (WiFi)	54 Mb/s	50 m
802.11g (WiFi)	54 Mb/s	100 m
802.11n (WiFi)	About 400 Mb/s	tens of meters

Table 4 WiMAX and Wi-Fi characteristics

WiMAX (Worldwide Interoperability for Microwave Access) technologies hold the best prospect of finding widespread use in practice since they surpass their competitors in every technical aspect. At transmission rates comparable to those of 802.11 (Wi-Fi), they provide connection over greater distance. The mobile variant, 802.16e, has no competitor at present. Also important to note is that WiMAX can provide a cost-effective broadband access solution in areas beyond the reach of DSL and cable. The ongoing evolution of IEEE 802.16 will expand the standard to address mobile applications thus enabling broadband access directly to WiMAX-enabled portable devices ranging from smartphones and PDAs to notebook and laptop computers[10].

3 Identified barriers and inhibitors

Mainly, broadband has wider usage in more developed countries and there mostly in urban areas. First reason for this is of course economic, since operators search for the profit and also coverage for large investment in equipment, development of technologies, services...This could be summarized as the "Demand" factor (demand for the broadband access and services is much smaller in less developed countries, and rural and remote areas). Other reasons are also limitations of technologies deployed in performances or in capacity (e.g. max 6 km distance from the ADSL exchange), or in case of wireless access, Line of Site (LOS) – Customer Premise Equipment (CPE) location from the wireless access base station. Even if such limitations is possible to overcome using other complementary backbones or equipments (optical fibers or microwaves links, remote switching units, etc), the extra cost of these new equipments, of their deployment and their operation directly impacts the business model. This is the cost factor[11]. Both the Demand and the Cost factors are the major barriers to the broadband access as identified by ITU shown in the following chart (Fig. 8).

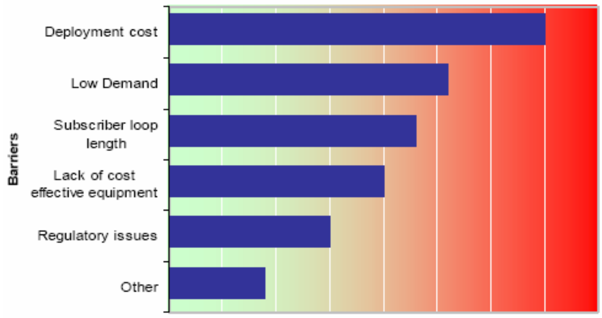

Fig. 8 Major Barriers to Broadband access deployment

Broadband is offering many advantages and useful services, but also some problems at other levels need to be solved. Currently, a large part of the network traffic is peer-to-peer file sharing, some of which concerns collaborative working and other legitimate uses, but most of which is downloading music, and, increasingly, movies over the Internet. For example, in Sweden up to 85%of a typical ISP's capacity was recently estimated to be used for peer-to-peer file sharing. As the intellectual property holders are getting ever more aggressive in pursuing unauthorized downloading, this may reduce the attractiveness of broadband.

A second problem is security. The always-on character of broadband connections makes end-user machines visible to the Internet. According to some estimates, most spam mail is now sent by broadband-connected consumer machines that have been converted to mail generators and gateways using security holes. Automated scanning tools enable systematic search of vulnerabilities in broadband-connected end-user machines, and several viruses have been created that do this without human intervention. As the number of broadband users grows, there is no guarantee that their computer security competences would quickly improve. If end users realize that machines in their homes are used to send spam and viruses across the world, they may start to view broadband connections as harmful and dangerous, which could have a negative psychological effect, preventing new users to become broadband users[12].

4 Conclusion

In order to realise the initiative of "Broadband for All" many important steps need to be taken. This paper provides a brief overview of some major Broadband technologies, presenting their advantages but as well barriers for their wider deployment and usage. Problems are not just of technical nature. Each country has its specifics, economically, demographically, geographically, politically. Praxis has shown that the most successful projects on broadband deployment were supported by the government which also managed to bring together various service and technology providers (e.g. South Korea). In some countries still the problem of regulation pertains, largely resulting in domination of incumbent operators. In order for broadband to fully develop, healthy and strong competition is necessary. Technologically looking, FTTx for wired access and WiMAX for wireless access can be seen as the currently most promising technologies which have ability to provide necessary bandwidth and speed for the e-services to come.

Acknowledgment

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