

# FUTURE BROADBAND ACCESS NETWORKS

## *Trends in user and service requirements*

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Abstract: The interest of the current study is to describe broadband trends in Europe based on the work performed within the BROADWAN project. The services and user experiences in broadband trials performed in Norway showed that always on, high-speed Internet access for PCs is a very popular service regardless of gender. The always-on feature changes the usage pattern of the services and leads to new ways of using broadband, such as increased use of music and movie downloading. For private users there is traffic all day and surprisingly high traffic loads from midnight until dawn, with some reduction during working hours. A small fraction of the private users dominates the traffic volume, and for these users the traffic towards the network exceeds the incoming traffic volume. Future user behaviour is expected to follow the trends of the users currently classified as demanding. Broadband networks must have capability to offer the individual user a capacity that can be asymmetric on demand in both directions. A breakthrough for capacity demanding e-services will require that the majority of users reach a certain activity level. Volume growth of these more demanding services requires that a large fraction of the population be connected to broadband. Additional key elements required are confidence and trust in e-based services by handling security issues seriously, overcoming the language barrier, standardised online payment methods and solving copyright issues.

## 1 INTRODUCTION

Broadband is far more than high-speed networking: it is a technology that gives growth impulses to the economy, creates more productivity and opens new markets. The utilisation of broadband networks is regarded increasingly more important for the development of the European society. Broadband services facilitate and may even be absolute necessary to maintain and increase the everyday quality of life, irrespective of living area. Business, organisations, education, health care, cultural, community and national authorities are obtaining more and more benefits from broadband networks. Service convergence is expected to

include traditional communication and broadcasting services as well as provision of Internet, music, video and games in a multi-service high-speed network.

This paper presents some early results from the partly EU funded project "Broadband services for everyone over fixed wireless access networks (BROADWAN)" [1]. The scope of the project encompasses a total solution for universal hybrid broadband access networks, including deployment guidelines and planning software, with a focus on wireless access architectures and systems. The results presented in this paper cover trends in user and service requirements with a scope of five to ten year into the future.

The paper is organised as follows. Trends and driving forces in the development of broadband to all in Europe are discussed in Section 2. User observations from trials on hybrid broadband access performed by Telenor in Norway are presented in Section 3 followed by service requirements in Section 4, based on several user characteristics. Finally, a set of conclusions is given.

## 2 BROADBAND TRENDS

Technology provides increased and new possibilities to users, network operators, service providers and content producers. Availability of broadband access to everybody has become a political goal of high priority and is considered a necessity for the building of the information society expressed in documents like the e-Europe plan. Broadband coverage is still rather low in Europe; for most countries less than 20 per cent and this is a bottleneck in the development of services like e-learning and e-health with availability for all regardless of location.

The limited deployment of broadband access also sets a limitation on the development of broadband interactions between individuals and groups of individuals. The starting situation of today is broadly represented by data delivery services from central nodes such as web and ftp, and interactions within and between organisations. The main issue that gives the mobile domain strength is connecting people. The same effect will start developing for broadband access when population coverage, or more precisely, participation, becomes sufficiently high, anticipated to be in the range 50 to 70 per cent. We may then see a development where authorities at different levels can reach all citizens and communication between individuals and communities will develop as point-to-point, point-to-multipoint and multipoint-to-multipoint type of interactions.

The total number of fixed telephony lines has started to decline. The trend is now that young people have a broadband connection and a mobile phone. IP telephony is gradually being offered as part of the broadband connection, in particular by new operators. With IP telephony there will be more flexibility. It will serve as both fixed and nomadic, and mobile services like MMS can be adopted at a lower cost. Combining audio and video opens up for development of a broad range of IP based telephone services. With everybody having a separate IP address for the phone the location based identity assignment is gone. 3G and 4G telephone services may be very similar for the mobile and for the IP-

based broadband networks.

Services such as Internet telephony (VoIP), TV in the form of IP multicast (Broadcast on demand) and with audio/video services/traffic between individuals is starting to take off. In the same period there will be a strong technological push represented by

- Increased capacity and functionality of PC and storage systems in combination with efficient high capacity in-house networking
- Capacity for advanced software packages for coding and decoding, editing and even language translation will give new possibilities
- New digital devices like cameras, home cinemas, surveillance equipment will become common and create traffic as well as making it possible to produce and deliver content from any location
- New possibilities resulting from the use of IPv6 or other more advanced protocols

There is a significant difference between the Internet usage in Western and Eastern Europe: By 2005 it is expected that half of the population in W-Europe will have Internet access, whereas only 20 per cent of the Eastern European citizens will be able to go online. Dial-up or modem is currently the most widely used Internet access mode in the Central and Eastern European countries. Broadband services could close the gap between the developments of these two regions by providing affordable broadband services also for less developed regions of Europe.

### 2.1 Development in wired broadband access

Asymmetric digital subscriber line (ADSL) technology has been available since 2000; currently this is the fastest spreading broadband technology. The Internet bandwidth parameters of the cable systems are similar to that of ADSL, however, it is very different from ADSL from a service provision point of view. Cable can provide triple play, including TV, data (Internet) and telephony. After a short operational period of ADSL the capacity limitations became clear and ADSL2 and ADSL2+ were introduced recently. With ADSL2+ downlink capacity is increased to 20-25 Mbit/s, but for a coverage distance limited to about 1 km. This would allow ADSL to offer also triple play delivery. The penalty of increasing capacity is a shorter coverage range seen from the DSL access multiplexer (DSLAM). Very high rate digital subscriber line (VDSL) operates over the copper wires in the phone line in much the same way that ADSL does, but

there are a couple of distinctions. VDSL can achieve speeds as high as 52 Mbps downstream and 16 Mbps upstream. That is much faster than ADSL. However, the performance in terms of transfer speed comes at a price; VDSL can only operate over the copper line for a short distance, about 6-800 m.

Leased line and the fibre optic technologies are mainly used by corporate users and backbone networks, not currently by private users or SME's. In the long run the fibre optic has future, as the development of the technology is very promising and there is already a move towards the use of fibre connections also to the private user.

## 2.2 Wireless broadband access

The interests and needs of broadband users in remote areas may differ from those in cities and more populated areas. The importance of teleworking, remote education and remote health services are of higher importance here. Broadband fixed wireless access (BFWA) is a good alternative to ADSL and interactive cable solutions, especially in rural or less developed areas. An increasing demand for BFWA is arising in Central and Eastern Europe, owing to the lack of any suitable wired infrastructure.

Efficient wireless access systems ensure that everyone in Europe can get access for broadband services within a reasonable time frame. Radio based solutions offer:

- Flexible and scalable on-demand capacity
- Coverage in areas not reached by wired solutions
- Stand alone solutions for full coverage
- Competition with established broadband wired technologies
- Simple extension to nomadic users

Radio access solutions can be adapted to varying population densities and user capacity demands through use of different frequency bands. They can provide high capacity for dense populations in the higher frequency bands (above 20 GHz) and cover larger less populated areas at lower frequencies.

Local Multipoint Distribution System (LMDS) is a high capacity cellular technology operating in the frequency range above 20 GHz. The advantage of operation in these high frequencies is the large frequency bands and thus capacity available. The LMDS technology was a first generation technology of BFWA.

The WiMAX-backed IEEE 802.16a standard for 2-11 GHz is a wireless metropolitan area network (Wireless MAN) technology that provides broadband wireless connectivity to fixed, portable

and nomadic users. It can be used to backhaul WLANs to the Internet, provide campus connectivity, and enable a wireless alternative to cable and xDSL. It provides up to 50-kilometers of service area range, allows users to get broadband connectivity without needing direct line of sight with the base station, and provides total data rates of up to 280 Mbps per base station sector antenna.

Wireless Local Area Networks (WLAN) are in many cases substituting cable based LAN's. Typical locations where hot spot service will be offered initially include hotels, airports, supermarkets and similar places where demand for nomadic broadband data services is high.

Free space optics (laser beam) allows theoretically the same transmission speed as fibre optics. Transmitted through the air, the weather conditions (fog) limits its capable bandwidth and distance.

The satellite systems are used to broadcast TV and radio programs, but are also used for communication and Internet transmission purposes. The interactive DVB-RCS system was developed by adding a return channel to the DVB-S system. Standardisation is right now under way to adopt the return channel (RCS) to the new DVB-S2 standard providing higher throughput and thus reduced cost. An increased volume in the broadband market is expected to justify new development including user-to-user connectivity via one satellite hop and use of multibeam technology for increasing capacity and lowering cost. It should be noted that the technology has definite advantages when broadcast and multicast can be applied.

User observations from several trials on broadband access in Norway are in the next section used as basis for home user characterisation.

## 3 RECENT USER OBSERVATIONS

The first challenge for a sound development of a heterogeneous access network is to estimate the needs and interests of the users under the assumption that the population as a whole gradually will have broadband access connection as well as the ability to use it. Estimating capacity needs involves a focus on the development of users groups, which again requires segmentation. Development trends among users, specific needs associated with availability and cost, the educational needs of society and individual users and technology usage are all among the factors, which have influence. Some trends are observed from ongoing or recent trials, other has to be anticipated, but a first study of the existing development trends gives important ideas about near

term development trends.

The users of broadband access networks extend from individuals fixed and nomadic users to commercial organisations and public authorities, with some acting as both content providers and consumers of information. Base station feeder links for 3G mobile networks and wireless LANs are other categories of usage. Rural users and users in less developed areas are of special interest to the BROADWAN project.

Available traffic and service data from trials as well as from operational broadband systems give an indication on user behaviour and traffic development [3]. It should be noted that the trial data are often obtained under special and the interpretation of the measured data is not always straightforward. The users in the reported trials were all private users (families) with different high-speed Internet connections to their homes.

### 3.1 Users and capacity

The first results are based on regular broadband service provision to apartment houses in Oslo, Norway [3]. Each of 2242 apartments was equipped with 10 Mbit/s access paying a fixed monthly fee independent of the traffic volume. The capacity consumption towards the users as well as the information generated and transferred to the Internet during 2-weeks is shown in Table 1.

Fraction of total / User group	Traffic characteristics	
	Total volume (GB)	From user/to user
Top 1 %	103	2.27
Top 5 %	41	1.83
Group 1	13	1.79
Group 2	0.5	0.47
Group 3	0.13	0.26
Group 4	0.04	0.18
Group 5	0.01	0.15

Table 1. Traffic and user groups, 2-week period [2]

The total traffic volume to all users was 7.8 GB with an average data transfer speed (throughput when using the services) of 7.8 Mbit/s. The average traffic per household during this time period was 840 MB.

The table shows a situation where the users with low consumption volume have the typical www browsing asymmetry, while the consumers of high volumes of data show the opposite trend; outgoing traffic dominates. The total traffic is dominated by a small fraction of the users. The information in this table reflects some of the problems under discussion.

Most of the users involved would do well with ADSL or ISDN connections. These technologies, however, do not have the capacity required to provide triple play type of services. The central question then is: how will service offerings and users behaviour develop in the future. Data like this explains why many users feel they are paying the bill for the demanding customer. It illustrates why many operators have started to offer so-called low capacity or low volume broadband connections at a lower cost. Whether this is a short term or a long-term market place is an open question.

### 3.2 Time variability of traffic

There is a need for data illustrating how a user group like this evolves with time. Looking into development there are several possibilities and phenomena to take into account. Many of the users are beginners and there may be a need for education. A breakthrough for e-services will require that the majority of users reach a certain activity level. Availability and active use of equipment for music and video handling will contribute to increased traffic. Volume growth of these more demanding services requires that a large fraction of the population be connected to broadband.

A recent Telenor trial offering high capacity via VDSL and LMDS in another area in Oslo, with a combination of dwelling houses and private houses showed that the users could be very demanding when capacity is free. Figure 1 [3] shows accumulated data traffic in bit/s for uplink, downlink and in total for a trial with duration of 33 weeks of 40 users connected to a local area Ethernet network offering triple play services.

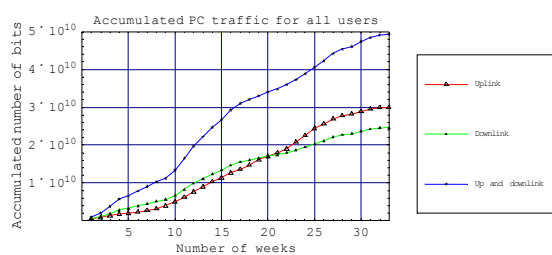


Figure 1. Accumulated traffic for 33 weeks

It is observed that accumulated traffic increases steadily throughout the period and in particular that the traffic from the users overcomes the incoming traffic after about 20 weeks. There is no indication that interest in utilising the Internet services is lost after a short period. The daily traffic also shows

some variations as illustrated in Figure 2 [3].

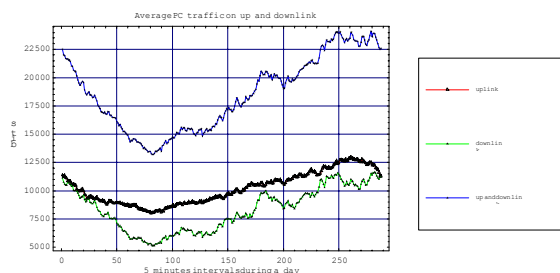


Figure 2. Average traffic variations during a day.

The variation in average traffic during a day is approximately 1:2, with highest, and close to symmetric, traffic around midnight. Traffic volume is lowest and asymmetry highest at about 6 in the morning. Thus there seems to be room for some additional business activity during the day. The variation during a week shows the same type of variation for every day but with highest traffic volume during weekends.

### 3.3 Discussion of results

The services and user experiences in the trials showed that always on, high-speed Internet to PCs was the most popular service offered, regardless of gender. The always-on feature changed the usage of the services and leads to new ways of using broadband, such as increased use of music and movie downloading. The findings suggest that users are more active when given always on access to the Internet as opposed to access that is preconditioned. It was observed that traffic into the network from the homes was far higher than in other Internet settings, indicating that access to broadband access increases users utilisation of applications generating large amounts of traffic. There is traffic all day and surprisingly high traffic loads from midnight until dawn with some reduction during working hours. A small fraction of the private users dominates the traffic volume, and for these users the return traffic exceeds the incoming traffic volume. Thus the network must have capability to offer the individual user a capacity that can be asymmetric on demand in both directions for fixed connections.

## 4 SERVICE REQUIREMENTS

The general requirement to broadband networks is to support a wide variety of services for the

different user groups, some acting also as content providers. Example services are e-health, e-learning, e-government and e-business, the latter enabling business communications between enterprises and individuals at any geographical location [4].

There are some key challenges to overcome before European wide utilisation of e-services is common. The usage of online-card payment varies from country to country. Systems for online payment by credit card have improved, removing one barrier to e-commerce growth. Techniques are still evolving, however, and goods ordered online may in some cases still be billed utilising traditional paper invoices. Development of electronic signatures may make e-commerce simpler, facilitating secure authentication [3].

An important aspect is consumers' trust and confidence in utilising e-services. The users expect their privacy to be protected, including security mechanisms for authentication, integrity, access control, and confidentiality. The security issues are considered imperative to ensure take up of broadband services by the general public, as transfer of personal and confidential information is a prerequisite for a waste number of public and commercial services.

Although a large portion of for example music downloads have been violating copyrights, legal and commercially successful download portals have been established by for example Apple (Ipod).

In addition we have factors such as user friendliness of equipment and services, language barriers and availability of broadband access to all.

## 5 CONCLUSIONS

Availability of broadband access to everybody has become a political goal of high priority and is considered a necessity for the building of the information society. Research on the Central and Eastern European countries showed that the telecommunication market in the region is very different from that in the Western EU countries and as a consequence specific measures have to be taken.

With all the new possibilities and the increased access network capacity users will have different sets of possibilities. It is no longer just to learn how to log on, send an email and find something on the WEB. There will be strong differences between users as a result of ability and interest. The problem of today of providing broadband connections is shifted towards the problem of educating the majority of a population to use the technology both for its own interest and in the building of an e-Europe including all of the population.

The services and user experiences in the Norwegian trials showed that the always-on feature changes the usage of the services and leads to new ways of using broadband, such as increased use of music and movie downloading. For private users there is traffic all day and surprisingly high traffic loads from midnight until dawn, with some reduction during working hours. Enterprises and schools have a short intense user period during daytime. A small fraction of the private users dominates the traffic volume, and for these users the traffic towards the network exceeds the incoming traffic volume. This type of usage is expected to dominate in the future, and future broadband networks must have capability to offer the individual user a capacity that can be asymmetric on demand in both directions.

A breakthrough for capacity demanding e-services will require that the majority of users reach a certain activity level. Volume growth of these more demanding services requires that a large fraction of the population be connected to broadband. Additional key elements required are confidence and trust in e-based services by handling security issues seriously, overcoming the language barrier, standardised online payment methods and solving copyright issues.

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