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Technology Requirements and Business Opportunities for Home Networks

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Problem Description

Internet, Digital television, IPTV and voice over IP are examples of services which change the way we work and live in our homes. Television, telephony and Internet have traditionally been separated services working independently, but the last years we have seen several companies delivering packages of services, all working over the same network.
Wireless connection is becoming crucial for many people. The need for being connected is also present when located in the garden, on the train and so on. Several of our most used electronic devices are portable and we expect to have the same utilization of the devices wherever we are located.
"The connected home" is becoming increasingly complex. From having telephone and television connections, we now have a complex network of various devices in our homes. Combinations of wiring and wireless solutions are not uncommon.
The changes in how we connect and retrieve content from the outside world create both technical and business related challenges. The way we pay for content and services will change, and new business models must be created and evaluated.
This thesis deals with the development and foresights of home networks. What are the general needs in people's homes? How can network providers deliver these new services? What are the technical demands and limitations for home network solutions? How will setup, configuration and support of advanced home networks be handled? How will the new home networks affect the traditional business models?

Assignment given: 17. January 2007
Supervisor: Leif Arne Rønningen, ITEM

Preface

This master thesis is written by Knut Magnus Backer from January to June 2007. The work is the final part of a master degree at Department of Telematics, at the Norwegian University of Science and Technology.

I would like to thank my supervisor Harald Øverby and Professor Leif Arne Rønningen for advices and help during the work.

Oslo, June 14`th 2007

Knut Magnus Backer

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List of Abbreviations

3G	Third Generation
ADSL	Asynchronous Digital Subscriber Line
BRAS	Broadband Remote Access Server
CAPEX	Capital Expenditures
CAT5	Category 5 (Ethernet Cable)
CE	Consumer Electronics
CM	Cable Modem
CMTS	Cable Modem Termination System
CN	Communication Network
CSMA / CA	Carrier Sense Multiple Access / Collision Avoidance
CSMA / CD	Carrier Sense Multiple Access / Collision Detection
DHCP	Dynamic Host Configuration Protocol
DOCSIS	Data Over Cable Service Interface Specification
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DVB	Digital Video Broadcasting
EPG	Electronic Program Guide
FTTB	Fibre To The Building
FTTC	Fibre To The Curb
FTTH	Fibre To The Home
FTTN	Fibre To The Node
HDTV	High Definition Television
HFC	Hybrid Fibre Coaxial
HomePNA	Home Phone Networking Alliance
ICT	Information and Communication Technology
IP	Internet Protocol
IPTV	Internet Protocol Television
ITU	International Telecommunication Union
LAN	Local Area Network
LCD	Liquid Crystal Display
LLUB	Local Loop Unbundling
MIMO	Multiple-input Multiple-Output
MOCA	Multimedia Over Coax Alliance
NAT	Network Address Translation
nPVR	Networked Personal Video Recorder
OAM	Operation and Management
OFDM	Orthogonal Frequency-Division Multiplexing
OPEX	Operation Expenditures
P2P	Point to Point
PDA	Personal Digital Assistant
PDU	Protocol Data Unit

PLT	Power Line Technology
PoE	Power over Ethernet
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PPP	Point to Point Protocol
PSTN	Public Switched Telephone Network
PVR	Personal Video Recorder
QoS	Quality of Service
RG	Residential Gateway
RMS	Remote Management System
ROI	Return On Investment
RTSP	Real Time Streaming Protocol
SDM	Spatial Division Multiplexing
SDSL	Symmetrical Digital Subscriber Line
SDTV	Standard Definition Television
SN	Service Network
STB	Set Top Box
TDMA	Time Division Multiple Access
UDP	User Datagram Protocol
UI	User Interface
VDSL	Very high bit-rate Digital Subscriber Line
VoD	Video on Demand
VoIP	Voice over IP
WAN	Wide Area Network
WAP	Wireless Access Point
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network

Abstract

Broadband connectivity has increased significantly the last years. More and more households choose to subscribe to services from various broadband companies. This has led to a range of new services. Some of these have high demands to both bandwidth and quality of service. Network operators have until recently neglected the challenges of providing network coverage within customer homes. Wireless solutions have been widely used, but new and demanding services like HDTV will either need a wired network or a significantly improved wireless standard. The complexity of in-home connectivity has increased dramatically because of a constant increasing number of devices and severe technical requirements. Convergence of earlier separated services is one of the main reasons for these new technical challenges. Different services with various demands are delivered over the same physical pipeline. The convergence of television, Internet and voice services, known as triple play, is delivered by both cable and fibre network operators today. Telecom operators are looking for ways to deliver triple play to compete in this new market. In addition to technical challenges, high costs and uncertain revenues slow down the development.

In this thesis, we look at general technical requirements as well as business aspects regarding the development of a home network solution. Various technical solutions for in-home wiring are discussed. Because of high costs attended with installation of new wires in people's homes, usage of existing wiring is recommended. Power line technology (HomePlug) as well as data over coax and copper (HomePNA) are presented as actual solutions. Wireless LAN standards are mentioned and the new 802.11n standard is recommended as the next WLAN solution to be embedded in the future home network. The support of Ethernet is also recommended beacause it is well proven and delivers high bandwidth as well as low latency and jitter. The support for these various interfaces should be embedded in the Residential Gateway (RG) which is delivered by the network operator and resides in the transition between the access network and the home network. The RG is "the brain" in the home network and controls all services. One of the main tasks for the RG, is to deliver the appropriate Quality of Service (QoS) for the different services. This is done through a remote management system that ensures end-to-end QoS.

The establishment of triple play leads to changes in existing business models. Telephone companies, broadcasters and cable network operators are among the involved actors. How to increase customers' value and how to ensure return on investment are central questions regarding the development of a triple play business model. Revenues must be ensured to get acceptance among stakeholders. A general business model for a network operator launching triple play is presented in the thesis. The model is based on a pre-defined business model ontology and uses elements from the involved actors' existing models. The establishment of the "connected home" which emphasize ease of use and personalization is central in the proposed value proposition. A home network user interface accessible from the various in-home devices is recommended to ensure customer control and user friendliness. Services like video on demand, personal video

recording, interactive television and Internet should be accessible through the user interface. The network operator should differentiate from competitors by offering their customers a complete home network solution where ease of use, performance and personalization are emphasized.

Partnerships with actors in the content and advertising industry as well as equipment manufacturers are discussed. To ensure low cost and high quality equipment as residential gateways and set top boxes, good partnerships with equipment manufacturers are essential. TV channels and independent content must be retrieved through partnerships with the copyright holders of the content. By making content available independent of TV-channels, network operators can take over parts of the television business which is operated by broadcasters and television programmers today. VoD and pay-per-view services will probably gradually take over for existing television services. Network operators have a golden opportunity to take over great shares of this business.

Advertising can generate important revenues for network operators. The ability to personalize advertisements and offer shopping directly from the TV-set increases the value of advertising. Commercials can be displayed in the home network user interface and in connection with services as video on demand. Content with commercials attached can be offered at reduced price or for free, hence intercepting the customers with low willingness to pay.

The financial aspects regarding home network solutions are discussed generally and with a low detailing level in this thesis. Huge costs are connected with the development of triple play and home network solutions, but there is also a high potential for revenue generating services and income from advertising and shopping. But, to generate any revenues, the network operator is dependent on customers. Hence, acquiring and retaining customers by delivering highly valued services and good customer support is the key to success.

Chapter 1
Introduction

Since the Plain Old Telephone Services (POTS) were introduced in the late 19th century, our connectivity with the outside world has developed dramatically. Television has brought live pictures to people's homes for decades. Terrestrial, cable and satellite networks have connected our TV-sets to the broadcasters. Around 1980, people started to send documents through fax machines and with the 90's, Internet access through dial-up modems became available for the mass market. During the last years, broadband connections have gradually replaced people's dial-up connections and new services have become possible. (About.com, 2007) Internet has evolved from mainly offering web-browsing and e-mail to delivering Internet Protocol Television (IPTV), Voice over IP (VoIP), online gaming, video conferencing and much more. Internet Service Providers (ISPs) have so far constantly improved their infrastructure which has given higher bandwidths for their customers. Various technologies are being used to provide broadband connections. DSL, cable and fibre technologies are among the most common. (Webb & Howard, 2005)

1.1 Motivation

Within broadcasting, the Digital Video Broadcasting (DVB) standard has introduced improved functionality, new TV channels and increased quality for digital television. (DVB, 2007) Digital television is today mainly transmitted through satellite, cable or terrestrial networks. The last years, many cable TV operators have started as ISPs in addition to deliver TV channels. They deliver Internet connection to their customers by enabling two-way communication through the existing Hybrid Fibre Coaxial (HFC) infrastructure. Telephone companies and the traditional ISPs are feeling threatened by this new actor in the broadband market. VoIP has made cable companies able to deliver television, Internet connection and telephony over the same infrastructure. This combination is often referred to as "triple play." The customers get an "all in one" package and receive only one bill for all the services. The cable companies are still the leading provider of such package solutions, but several companies building fibre networks are offering similar services. (LYSE, 2007) The telephone companies are looking for ways to deliver television over their existing infrastructure to compete in this new market situation. (Nanjie1, 2006)

Services which earlier worked on separate platforms have started to converge and may today work together by using new standards and protocols. (Yanovsky & Koch, 2002) This will radically change the way devices like telephones, TV-sets and computers are connected in our homes. We see that an increasing number of devices in our home can work and communicate through the same network. Instead of connecting the TV to its

coax, the telephone to the PSTN contact and the laptop to the DSL modem, we can establish a common network for all of these services. This is what we call the home network. (EURESCOM, 2005)

1.2 Challenges with the future home network

When we establish a home network which connects various devices dispersed around our home, we face challenges not present in former network solutions. Services have to be differentiated and given the appropriate Quality of Service (QoS) in the network. Different service classes must be used to be able to prioritize some traffic ahead of other. When all services are transported as IP traffic, each Protocol Data Unit (PDU) must be evaluated to determine which service the PDU belongs to. Then the network operator must ensure that the service gets the QoS appropriate for the actual service class. This is one of the major challenges when handling future home network solutions. (Emstad, Heegaard, & Helvik, 2004)

We also have to adjust the service quality to the respective device. We have a wide variety of devices with various capabilities. Television sets, laptops, mobile telephones and PDAs have different demands regarding QoS and bandwidth. When we watch the 50" LCD screen in the living room, we want the best possible quality. In contrast, we cut it fine with a reduced resolution when watching video on portable devices like PDAs and mobile phones. Mobility is also an issue in the home environment. Portable devices need wireless connection, while large TV-sets are stationary and have strict demands regarding bandwidth and QoS. Hence, home networks must differentiate service quality depending on the respective device and maybe offer both wireless and wired connections. (Adams, 2006)

A well functioning scheme for set up and maintenance of home networks is crucial to ensure customer satisfaction and business success. Customers need a well functioning system that is easy to follow. An additional device added in the home network should configure itself and demand as little as possible from the users. How billing of the services shall be organized is another challenge. Billing based on content and service classes makes it necessary to inspect all traffic to and from the customers. How these challenges shall be solved and where in the network the controlling elements shall be placed are central issues when evaluating home networks. (HGI, 2006)

The convergence of earlier separated services as television, Internet and telephony will not only lead to technical challenges. Involved actors face a new market situation and their existing business models will no longer be useful. Hence, new business models must be created to form a consensus of how the new business shall be run among the involved actors. Good business models are crucial to succeed in the complex market where many actors with different interests are involved. (Nanjie2, 2006)

1.3 Problem Definition

Convergence of Internet, television and telephony does not only create challenges in access networks, but also within each home. The complexity of home networks becomes radically increased when a diversity of services are delivered through the same network. As we mentioned in the first section, we face several challenges regarding interconnection of devices and management of the compound home network.

Today's homes seldom have a wired data network established and most people choose a wireless network due to their very simple installation, cheap price and satisfactory operation with today's requirements. But, we see that coming services like IPTV will be too demanding for today's established wireless solutions. Hence, we will either need an improved wireless technology or a wired network for distribution of television signals in the home network. One of the major challenges with the future home network is the establishment of a satisfying and not too costly network infrastructure. (HGI, 2006)

In addition to the physical interconnection, we need something to control and manage the home network. Services have varying needs and must be differentiated within the network. The services might be delivered by several providers independent of the network operator. Authorization and billing schemes must be established and managed by one or several controlling units. The term "residential gateway" is often used for such control units which reside in the transition between the access and the home network. (Hartog, Jong, Balm, & Kwaaitaal, 2004) To make a complex home network manageable and functional, strict control routines and constant management must be performed. The residential gateway is very central in these operations and needs carefully considered design and functionality. (HGI, 2006)

Actors within broadcasting, telecom and Internet have traditionally operated separately and not as competitors. When their services converge, the borders cross and both competition and partnerships will occur. There are many questions and few answers to how this new business situation shall be run. (Nanjie2, 2006) The costs by developing the future home network will for certain be very high. Who shall pay the bill and how can the developers ensure a return on their investments? To get anyone to stake on these costly solutions, good business models that decrease the uncertainty must be developed. (McCartney, 2006)

In this thesis we will give a presentation of the future home network. We will look at services that will be vital for the design and technical solutions used to form the home network. We will present existing technologies and solutions as candidates for physical interconnection of devices and residential gateways. Business aspects will be discussed and a general business model will be provided.

In this thesis, we will try to answer the following problem statements:

1. What are the paramount technical requirements to the future home network?
2. What existing technologies and solutions can be used to satisfy these requirements for the next generation of home networks?
3. How will the convergence of services and the establishment of "the connected home" affect existing business models?
4. How can a network operator increase customers' utility by offering new home network solutions?
5. How shall network operators generate revenues and return on their enormous investments?

1.4 Limitation of Scope

In this thesis, we place emphasis on technical and commercial aspects related to home networks. We will briefly mention various access technologies, but detailed information on each technology is beyond the scope of this thesis. Both the technical requirements presented and the commercial aspects discussed in the business model use a general network operator as basis. We do not distinguish between network operators using different access technologies, but rather present a general solution. Because of this generality, the detailing level is limited in parts of the thesis.

1.5 Report Overview

Chapter 2, Background:
In this chapter, we look at the incredible increase in broadband subscribers the last years. We present various access technologies and discuss their suitability for future home network solutions. The increase in bandwidth caused by the broadband development has led to many new and demanding services. We present several services, among others IPTV.

Chapter 3, Home Networking:
In this chapter, we focus on the future home network. Use-cases illustrate the usage of the next generation home network solutions. We look into requirements and technological challenges. Different technologies and solutions for creating the "connected home" are presented.

Chapter 4, From Technology to Business and Revenues:
From evaluating technical solutions, we move to business related challenges facing the development of triple-play services and the home network. We look at how convergence affects existing businesses and how a new business model can be created.

Chapter 5, The Business Model:
In this chapter, we develop a general business model for a network operator delivering triple-play and home network solutions. Among other things, we explain what value our solution brings to customers, who we shall cooperate with and how a return on the investment can be obtained.

Chapter 6, Discussion & Conclusion:
In this chapter, we discuss the technical solutions presented in chapter 3 and 4. We give our recommendations to which technologies to pursue. The results from the business model in chapter 5 are also discussed. Finally, we conclude the thesis by answering the problem statements given in section 1.3.

1.6 Own Contributions

The work presented in chapter 2 – 4 is mainly based on existing literature, white papers and articles referenced to in each section. Chapter 5 – 6 are mainly own contributions provided that no other references are given.

Chapter 2

Background

2.1 Broadband development

During the last years, the number of households installing broadband has constantly increased. The number of broadband subscribers in OECD increased by 33 % from June 2005 to June 2006. (OECD, 2006) Northern European countries have the greatest penetration of broadband users. In Norway, 55 % of all households had installed broadband by the end of 2006. (Norwegian Post and Telecommunications Authority, 2007) As we can see of the diagram in figure 2.1, the growth of subscribers has been enormous the last years. We clearly see that xDSL (mainly ADSL) is the most common access type in Norway by the end of 2006. This is the case in most of the other OECD countries as well. Throughout this chapter, we will discuss various topics giving insight to the background for home networks. We will look into various access technologies, services run through the broadband connection and IPTV.

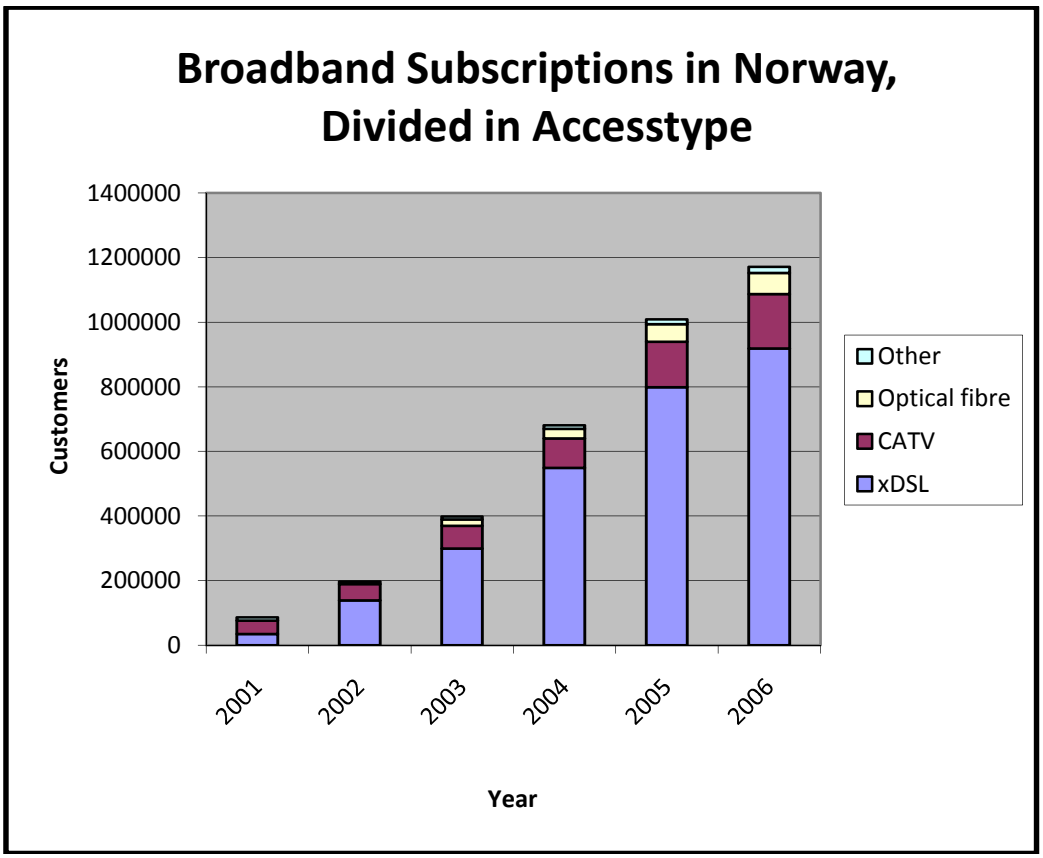

Figure 2.1: Broadband subscriptions in Norway from 2001 to the end of 2006. The total number of subscriptions is divided into parts indicating the number of subscribers per type of access network (Norwegian Post and Telecommunications Authority, 2007)

2.2 Access technologies

Many different access technologies are used to deliver broadband connections. Actors from the telecom and cable industry as well as new fibre optic network operators are using different access technologies to reach their customers. Even though access technologies not are our main focus in this thesis, we will give a quick overview of the technologies used by the various actors.

2.2.1 Digital Subscriber Lines

Digital Subscriber Lines (DSL) is a technology which provides broadband connection (typically at multi-megabit speeds) by using existing copper telephone lines. DSL exploits unused frequencies and allows high speed data and voice (POTS) to be sent simultaneously. There exist several variations of the basic DSL technology. Asynchronous DSL (ADSL) is the most common with more than 60 % market share worldwide. (DSL Forum, 2005) ADSL offers differing up- and download speeds and can provide up to six megabytes per second download speed for the customers. The maximum speed which can be provided to customers depends on the distance between the customer and the nearest Digital Subscriber Line Access Multiplexer (DSLAM). Long distance gives less bandwidth. ADSL2 is an improvement to ADSL and provides slightly higher bandwidth. ADSL2Plus provides twice the bandwidth and can deliver bit rates up to 20 Mb/s on relatively short lines. Very high bit rate DSL (VDSL) can deliver up to 26 Mb/s over distances up to 50 meters and can also be configured in symmetric mode. VDSL is currently used to test video services over the existing phone lines. VDSL2 is the second generation of VDSL and gives a better rate per reach. VDSL2 specifies several profiles including all from 100 Mb/s symmetric transmission on loops up to 100 meters to asymmetric transmission with downstream rates between 10 - 40 Mb/s on loops from 1 to 3 kilometres. Symmetrical DSL (SDSL) is one of several symmetrical DSL variations. Equal speed upward and downward can be very useful for purposes like hosting of web services. (DSL Forum, 2007)

2.2.2 Cable

Most cable TV operators offer broadband connection in addition to their television offer. The international standard DOCSIS (Data Over Cable Service Interface Specification) defines the communications and operation support interface for offering high speed data over cable systems. (CableLabs, 2005) This makes it possible to transport both television signals and high speed data over the same Hybrid Fibre Coaxial (HFC) infrastructure. (Cisco Systems1, 2006) Several versions of the DOCSIS standard have been developed. The basic architecture includes a Cable Modem (CM) placed at the customer premises and a Cable Modem Termination System (CMTS) located at the cable company's head-end. The CMTS can be compared to the DSLAM in the DSL network. The CMTS hosts downstream and upstream ports and routes traffic between customers (CMs connected to the HFC) and the Internet. The cable company has full control over the customers' CM configuration through the CMTS. The transfer rates provided by cable companies vary a lot. Technically, bandwidths over 100 Mb/s are possible both downstream and upstream with the latest DOCSIS standard. (Wikipedia1, 2007) Usually, cable companies offer bandwidths in the range 1-25 Mb/s downstream and 250 kb/s to 2 Mb/s upstream for private customers. (Get, 2007)

2.2.3 Optical fibre

Fibre To The Home (FTTH) is a technology based on end to end optical fibre between the central office and the customer's home. By using optical fibre directly to the building providers can offer significant higher bandwidths than other available technologies are capable of. FTTH is deployed using two specific configurations. The first one is called P2P (Point to Point) and here is one fibre dedicated to each user in the access network. In the second configuration, one fibre is shared among several users (normally between sixteen and thirty-two) by using a power splitter. This is called a Passive Optical Network (PON). The bandwidths in FTTH solutions vary between the two configurations and the protocols used on each configuration. In a PON, the bandwidth of the fibre will be split among the users. By using for instance the GPON protocol, users (up to 32) can share 2.5 Gb/s dynamically both downstream and upstream. (Kunigonis, 2007) Hence, FTTH networks are superior to DSL and Cable networks regarding bandwidth. Combinations of fibre optic networks and for instance VDSL are not unusual. FTTN (Fibre To The Node), FTTB (Building) and FTTC (Curb) are fibre networks where the optic fibre terminates outside the customer premises and another technology is used for the last distance into each home. This is usually some DSL technology using the existing copper telephone lines. FTTH solutions are costly to install because the fibres have to be laid into each home. Both the equipment, including the fibres as well as the receivers and senders, and the work by laying the fibres is expensive. Hence, many subscribers shrink from installing fibres in established homes. In new buildings, fibres are often installed together with electricity and other infrastructure. This is one of the reasons to why many of the traditional power companies have become leading suppliers of FTTH solutions. (IDATE, 2007) and (Kunigonis, 2007)

2.2.4 Satellite

Broadband connection via satellite is mainly widespread on rural locations where DSL, cable and fibre technologies not are available. As long as you can set up a satellite dish with free view toward the southern sky, you can obtain connectivity. This makes broadband over satellite attractive on desolated places and for mobile units like ships. But, it certainly has its drawbacks as well. Connection via satellite is costly and has large latency due to the long distance between the satellite and your receiver. The maximum bandwidth is not as good as DSL and cable connections offer, but acceptable for most purposes (~2 Mb/s). (Wikipedia2, 2007) and (Internet Service Deals, 2007)

2.2.5 Wireless

Wireless broadband connections exist in several variations. The most common and well known is the 802.11 standard (WiFi). This wireless standard has limited range and is therefore mainly used as a substitute for cabled Ethernet within office and home environments. But, WiFi has also been used to offer broadband connection outdoor in city centres and in cafés, restaurants and other public locations. WiFi uses radio waves to transmit data between the Wireless Access Point (WAP) and a computer's wireless adapter. The 802.11 standard have been deployed in several variations, separated by letters (i.e. 802.11g). Today, the bandwidth is limited to 54 Mb/s, but a new version called 802.11n has been announced and will deliver significantly higher bandwidth and wider range. If the range of WiFi improves, this might become an actual challenger to the present DSL, cable and FTTH suppliers. (Gast, 2005) Another technology widely discussed and proposed as a challenger to the existing access networks is WIMAX.

WIMAX is a standard for high speed point to point or point to multipoint data communication. In contrast to WiFi, WIMAX is designed to function over longer distances and not only within a very limited environment. WIMAX is currently in a pre market stage and there is excitement regarding its further development and success. (WiMAX Forum, 2007) and (WiMAX Forum, 2004)

2.3 Services over broadband

As we outlined in the introduction to this chapter, broadband subscriptions have increased remarkably the last years, and are still increasing. Web surfing, e-mail and shopping over Internet have become everyday tools for most people. We are using the home computer more and more. According to (Taylor, 2006), the average person spent 30.5 hours per month using their home computer in 2006, while we spent 25.5 hours on average per month in 2004. This is a significant increase in only two years. Broadband has given people greater freedom when it comes to using Internet. We do not need to dial up and manually log on to be online. Because you are "always on" with broadband, it is easier to sit down for a couple of minutes to read the news or check your e-mail. Broadband has made Internet to one of the most important news sources in our home. Many people choose to read news on the web rather than buying newspapers daily. The web is always up to date and provides fast access to what you find interesting. (Horrigan, John B., 2006) Due to higher bandwidth, broadband has made it possible to stream rich content as video and sound in acceptable quality. Radio and video streaming as well as music download have become common services on most news sites. (Taylor, 2006) We will now look at some of the services available through broadband connections.

2.3.1 Voice over IP

Voice over Internet Protocol (VoIP) or Internet telephony is routing of voice traffic over an IP based network. By using VoIP, only one single network is utilized to carry both voice and data traffic. VoIP has several advantages compared to traditional telephony: (Wallingford, 2005)

- Cost savings: VoIP providers can eliminate the cost associated with transporting voice over the traditional PSTN network. The cost of operating one network for both voice and data is lower than operating two separate networks.
- Open standards: By using open standards, service providers and customers can buy equipment from multiple vendors which increase competition and prevent lock-in to proprietary solutions.
- By focusing on one reliable IP network companies can quickly adapt to changes and new services in the constantly changing market for communication.

Various protocols and standards have been developed and are being used for VoIP solutions. Two main groups exist: Distributed and Centralized protocols. H.323 and SIP define distributed architectures for multimedia applications, while H.248/MEGACO and Media Gateway Control Protocol (MGCP) define centralized architectures. In centralized architectures, most of the network intelligence is centralized and the end-points are relatively simple. In distributed protocols, the network intelligence might be distributed

between the end-points. By end-points we mean any device that can initiate and terminate a VoIP call. We will not go into details of the various protocols, but rather mention that there exist several standards and protocols that can be used by providers. Because several protocols exist, each provider can choose the solution that fits their business and technical requirements. For more extensive information on VoIP see; (Wallingford, 2005)

As more and more households get broadband, services like VoIP gain increased popularity. To illustrate the growth in VoIP customers we have looked at the development in Norway the last year. From the end of 2005 until the end of 2006, Norway had a 98.5% increase in the number of VoIP subscribers. (Norwegian Post and Telecommunications Authority, 2007) It is no doubt that VoIP will continue to grow and capture constantly more customers along with the ongoing broadband development.

At the same time as the broadband penetration increases, we see that more and more devices are designed to utilize broadband to offer new services and more advanced functionality. Game consoles use Internet connection for multiplayer games, mobile phones are equipped with WiFi to connect to LANs and Internet, surveillance, heating and ventilation systems might use the broadband connection to offer remote control and management.

2.3.2 Online gaming

Online gaming has been popular for several years and started with simple games functioning over dial-up connections. When people played more advanced games, they gathered and played over a LAN. Today, we can play advanced multiplayer games with people located all over the world through our broadband connection. Microsoft introduced Xbox Live in November 2002 and this was the beginning of online gaming through game consoles. (Wikipedia4, 2007) Before the introduction of Xbox Live, online gaming was reserved for computer gamers. Today's network-enabled game consoles have created a larger market for online gaming. Gamers have created a serious business and 56% of the 117 million "active gamers" in the US play online. (Mokhoff, 2007) Online gaming has become a bandwidth consuming application and demands very low latency along with high responsiveness from both servers and infrastructure. Several large international companies including Microsoft, Intel an IBM are studying how to optimize broadband technologies to deliver improved services for online gamers and others who share bandwidth with the gamers. (Mokhoff, 2007)

2.3.3 Mobile devices

It is getting more and more common to design mobile phones and PDAs to connect to WLANs in addition to GSM, GPRS, EDGE and 3G networks. This makes it possible to utilize WiFi zones to connect to Internet, e-mail and other applications. Many mobile devices are equipped with advanced functionalities as cameras, mp3 players, e-mail clients, browsers and calendar systems. By connecting our device to the home or business network, we can frequently synchronize our mobile device with the other devices we are using. This is important to ensure backup and consistency of all data shared by our various devices. It is also possible to utilize our mobile device as an IP telephone when we are connected to a wireless network. By installing a piece of software, our mobile device can use the IP network instead of GSM when doing phone

calls. This will reduce customers' calling costs and improve the voice quality. By automatically detecting when a mobile device is in its home network, the device can adjust and switch to the IP network automatically. Hence, mobile devices will be a part of the total home network. (Gutberlet & Ruud, 2007)

2.3.4 Alarm and Surveillance systems

Security systems like alarms and surveillance cameras are widely used both for businesses and private homes. Alarm systems have for many years been connected directly to security firms through fixed or mobile communication. Today, we have more sophisticated systems utilizing the IP network both within the relevant building and between the building and a remote operator. Cameras connect directly to the IP network and communicate with a video server located on the same network. Several cameras and sensors provide both wired and wireless communication. The complete system can be remotely monitored and controlled through the video server. Most solutions provide remote monitoring through Internet via a browser, PDAs or mobile phones. By using such systems, users can monitor their own home when being away. If you are unable to monitor the home for yourself, a security firm can connect to your private video server and have full control over your home surveillance systems. Availability, stability and security are of course very important for such systems. Backup power supply and very stable WAN as well as LAN is crucial. QoS must be ensured both within the home network and between the local server and the remote operator. When several high quality cameras are connected, this can be a bandwidth demanding system. We can also think of other areas to apply similar remote controlled systems. Fire protection can be included by adding smoke detectors and heating and ventilation systems can be controlled by connecting sensors and controllers to the IP network. Examples of such alarm systems is presented in (GeniTronics, 2007)

2.3.5 Digital Television and IPTV

The Digital Video Broadcasting (DVB) project was started in 1993 and the first commercial digital broadcasts started via cable in 1997 in the US. (DVB, 2003) Today, most countries have adopted digital television and some countries have even closed down their analog networks. The DVB standard has several variations listed below. The different standards represent the various platforms or networks (DVB, 2007):

DVB-T	Terrestrial network
DVB-S	Satellite
DVB-C	Cable
DVB-DSL	Broadband
DVB-H	Mobile network (to handheld devices)

Digital television is a combination of computer technology and broadcast technology and has several advantages compared to analog TV. The TV signals are sent as compressed streams to the end-users. (Helps, 2005) Compression techniques as MPEG-2, MPEG-4 AVC and SMPTE VC-1 have made it possible to deliver high quality broadcast over limited bandwidth. (Olson, 2006)

To receive and decompress the digital TV signal, each television set needs an additional Set Top Box (STB) or a built in TV-tuner. Because of the advanced compression techniques, digital television can provide significantly more TV channels as well as radio channels over the same spectrum as analog TV did. The amount of spectrum space saved

by sending digitally depend on what compression technique that is used and the quality (resolution) of the broadcast.
Consumers experience improved picture quality and definition, better sound quality, more TV channels, possibilities to interactively control and participate in broadcasts, multimedia entertainment and shopping. Broadcasters benefit from lower TV channel and broadcasts costs, possibilities to broadcast more TV channels on the same spectrum and revenues from new businesses as t-commerce and shopping via the TV set. (Helps, 2005) The new opportunities and advantages with digital television are many. Even if digital television has been used for some years now, we have not yet seen the full utilization of this new technology. Broadcasters hesitate to stake on the new functionality available. Full utilization of digital broadcasting requires investments in STBs for each customer and software, hardware and infrastructure for the broadcasters.

Enhanced quality has been one of the main arguments for migrating to digital television. PAL has been the dominating TV standard in European countries and has provided a resolution of 768x576 pixels, which was very good for TV when PAL was firstly introduced. Thanks to technological progress, we have TV-sets able of displaying resolutions way above this today. LCD and Plasma displays with full HD resolution (1080p) have been available for some time and have now reached a price level which makes them attractive for more than just TV enthusiasts. Until now, most TV channels advertising with HD quality use the 720p or 1080i resolution and not 1080p which give full HD quality. (Canal Digital, 2007) HD-DVD and Blueray support 1080p and Xbox360 as well as Playstation3 will bring out games in full HD quality. However, it looks like broadcasters primarily will use the 720p and 1080i in the near future. In figure 2.2 and in table 2.1, we see an illustration of the most common resolutions used for television. (Wikipedia3, 2007)

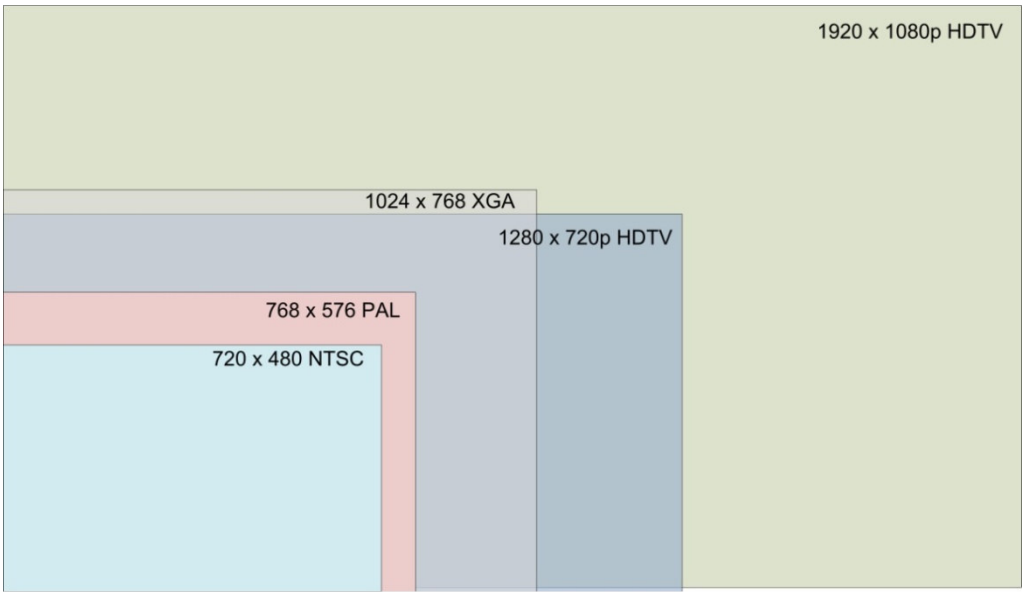

Figure 2.2: Illustration of the most common resolutions used for television. (Wikipedia3, 2007)

Name:	Resolution:
HDTV (Full HD)	1920x1080p / 1080p
HDTV	1280x720p / 720p
XGA	1024x768
PAL (SDTV)	768x576
DV NTSC / VGA (SDTV)	720x480

Table 2.1: Overview of the most used resolutions for television. (Wikipedia3, 2007)

In addition to deliver improved picture quality, digital television gives significantly better sound quality. Digital 5.1 surround is supported by most of the digital broadcasters. When the TV-set is connected to a HiFi system, users can enjoy a diversity of TV and radio channels with great sound quality. (Wikipedia3, 2007)

Electronic Program Guides (EPGs) have been announced as a new and useful feature in digital television. EPGs function as an advanced TV-guide which includes all channels' programs and schedules, film reviews, news, games, video on demand and so on. EPGs can be very useful and give important excess value for the customers. But, because of low processing power in the STBs and signal delays (especially in satellite communication) many users experience the EPGs to be too slow. If features like EPGs shall be convenient for the users, it must be fast and deliver a service comparable to other information channels as for instance Internet. (Helps, 2005)

IPTV

IPTV is digital television which is broadcasted through an IP network. The TV signals are sent in the form of IP packets through the IP network and reassembled to signals recognized by the TV-set in the receiver's STB. The STB is connected between the TV-set and the customer's broadband connection. (Rooney, 2006) Streaming of video content through the IP network can be done with for example User Datagram Protocol (UDP) and Real Time Streaming Protocol (RTSP) as higher level protocols. (Helps, 2005)
By connecting the STB directly to the IP network, we can make use of other IP based services directly on the TV. Web surfing, e-mail, messaging services, e-shopping and video on demand are all based on IP and can be easily be made accessible through the TV-set when connected to the IP network. The most important parts in a generic IPTV system are illustrated in figure 2.3.

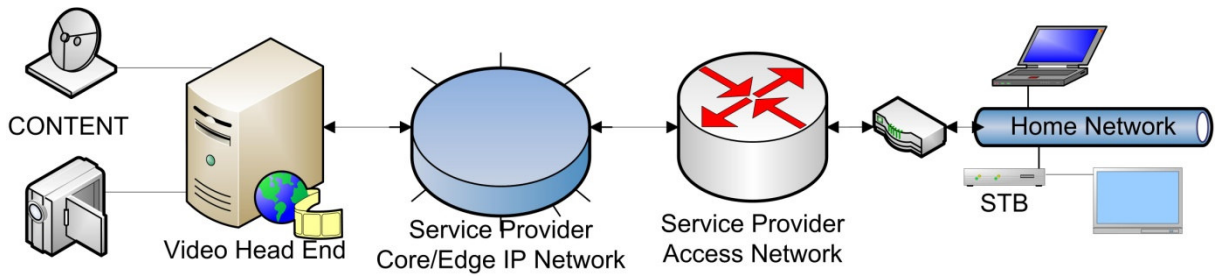

Figure 2.3: The major network elements in an IPTV system; from the video head end on the left to the home network on the right.

This illustration gives a high level overview and does not reflect the complexity and detailed architecture of specific implementations. The two-way connections between the various elements illustrate the opportunity to communicate in both directions. This gives IPTV several advantages compared to traditional television.

The video head end is where all video content is captured, encoded into a digital video format like MPEG-4, encapsulated into IP and sent out on the network. The streams are typically sent by multicast, but some vendors also make use of unicast. By using multicast, the service provider only needs to send one stream per broadcast from the video head end and to the access network. This saves a lot of bandwidth, especially when many users watch the same broadcast at the same time (e.g., live sport events). The service provider's core IP network transports the video streams from the video head end to the edge network where it connects to the access network. How the core networks are designed varies a lot between the various service providers. Some networks might be a mix of existing IP networks while others might be designed specially for video transport. (BSF Broadband, 2007)

The access network connects each household to the service provider's edge network. As discussed in section 2.2, the technology used here varies a lot. Copper, cable, fibre, satellite and other wireless technologies can all be used. A service like IPTV is very bandwidth consuming and will at least demand an ADSL2+ or VDSL connection. Each household needs a device which connects the access network to the house's home network. This device is often referred to as the residential gateway. (BSF Broadband, 2007)

The home network is an IP network which covers the necessary spots throughout the home. The most challenging with IPTV in the home network, is the great demand of bandwidth and Quality of Service (QoS) which is difficult to satisfy with today's wireless technologies. Hence some wire line technology from the IP network's entry point to the STB is often needed. Home networks will be studied further in the next chapter.

Within the STB, the IP packages are received and the video stream decoded and forwarded to the TV. The STB consists of processing hardware and software. The software part of the STB is referred to as the client side of the middleware. The IPTV middleware describes the software packages which are used to deliver the various IPTV services. Each IPTV service provider normally has their own middleware client/server architecture which controls the user experience through a user interface. (BSF Broadband, 2007)

Web-TV versus IPTV

Today, most TV channels have their own web-TV service where they publish their content. This gives the consumers the opportunity to watch their favourite programs when it fits them. Today's web-TV solutions are designed for being displayed on computers and not for large flat screen TVs. To be attractive for large screen displays, IPTV broadcasts must be of high quality with very good QoS. When people watch web-TV on their computer today, they accept limited quality and some delay and jitter. But when it comes to watching a soccer match or a movie on the new 42" LCD screen in the living room, most people expect high quality picture and sound and at least no delay and jitter. Hence, when we move today's web-TV into the living room and create a new IPTV service, we face totally different expectations and demands from the users. (Rooney, 2006)

Free distribution sites
Distribution of video material through the Internet has made it possible for independent TV producers to publish their content without significant costs. YouTube and similar free distribution web services where people share video content has really gained great popularity the last years. Today, the quality of the material on web sites as YouTube is very limited, but as the bandwidth of people's internet connections as well as the quality of camcorders, computers and TV sets improve, we will experience significant quality improvements. (FoxNews, 2006)

Bill Gates announced at CES in January 2007 that Microsoft shall deliver IPTV through Xbox360. He also declared his concerns regarding the future of the traditional broadcasts. Gates means that IPTV will take over for the traditional broadcasting and the audience will no more be passive watchers, but rather interactively participate in and control what they see. (VG Nett, 2007) There is no doubt that the way we watch television today will change. Digital television via terrestrial, satellite or cable networks and IPTV will bring new services to the customers. The TV-set will deliver much more than just TV channels with predefined programs. Internet connection, Interactivity, VoD, e-mail and e-commerce are examples of possible services through the TV-set.

2.3.6 Video on Demand

Video on Demand (VoD) is one of the services that can be made available directly from the TV-set when using IPTV. VoD is a pay per view service which gives the consumers freedom to watch what they want, when they want. Movies, news, sports and cartoons are examples of video content which can be delivered through a VoD service. VoD differ from a linear television service as the IPTV system provides a unicast stream to each customer. Controls like pause, fast forward and rewind is operated through the IPTV's middleware. (BSF Broadband, 2007)

2.4 Future bandwidth demands

It is no doubt that the future bandwidth demands will increase significantly compared to today's needs. By introducing HDTV over the IP network we get totally other bandwidth needs than we have today. The bandwidth required per channel in full HD depends on the compression technique used. By using mp4, each TV-channel normally requires 9-10 Mbps while an mp2 encoded channel requires up to 20 Mbps. (Harrop & Armitage, 2006) Tandberg Television announced in February 2007 that their new Ultra Compression Video Processing System can deliver two full-resolution HDTV channels over an ADSL2plus connection. They claim they can deliver 2 channels in 1080i resolution at data rates below 6 Mbps and 2 channels in 720p resolution at 4 Mbps. This makes it possible to roll out of IPTV on existing ADSL2plus infrastructures with simultaneous delivery of four SD channels or two HD channels. (Tandberg Television, 2007)

The number of TV-sets simultaneously used in each household will of course vary. Many people cut it fine with one TV-set while large families might have at least three different TV channels simultaneously displayed in their home. The number of simultaneous TV channels displayed in a home network is vital for the bandwidth consumption. Existing

services as file sharing, VoIP, e-mail, web-surfing and music streaming will continue to develop and must be included when evaluating the future bandwidth demand. File sharing will probably continue to be a popular and bandwidth consuming service in the future. The advantage by file transfers is their flexibility regarding delay, jitter and bandwidth. File transfers can make use of whatever excess available capacity in the network. Web surfing and e-mail will probably not change significantly in the future. Of course some higher bandwidth usage must be considered due to richer content on the web. (Harrop & Armitage, 2006) VoIP is not a heavy user of bandwidth. Actually, one voice channel only needs 24 Kbps using good compression algorithms as G.729. (Westbay, 2007) Stereo CD quality music can be streamed at as less as 128 Kbps using AAC. (Harrop & Armitage, 2006)

Summarized, we can see that IPTV will be the bandwidth "eater" for the future access networks. When several HDTV channels are desired simultaneously, high bandwidths will be necessary. We will not go into detail of these measurements, but rather demonstrate that radically higher bandwidths will be needed in the future. Details on measurements of future bandwidth demands can be studied in (Harrop & Armitage, 2006)

2.5 Summary

In this chapter, we have looked at how broadband subscriptions have increased dramatically the last years. In many countries the bandwidth penetration is over 50% and it continues to increase. (OECD, 2006) This development has lead to greater competition in the broadband market and several actors compete in the same markets. We have looked into the following access technologies:

- Digital Subscriber Lines (DSL)
- Cable Networks
- Optical Fibre (FTTH etc.)
- Satellite Networks
- Wireless Networks

This development in the broadband market has led to an increase in services using people's broadband connection. We have mentioned some of these:

- Voice over IP (VoIP)
- IPTV
- Video on Demand (VoD)
- Online gaming
- Alarm and surveillance systems

These new services and especially IPTV demand high bandwidth and high QoS. Hence, network operators have to constantly upgrade their network infrastructure to keep up with the demand. Such upgrades are costly and network operators are struggling to cover their expenses in an increasingly competitive market. In addition to these

challenges, we face an increasingly complex interconnection of in-home devices. As more and more devices in our home need access to other devices and services available in the IP network, our home network becomes exceedingly complex. How shall we manage to connect all these devices? How can the devices work together? What are the costs of establishing a home network? How can each service be guaranteed the appropriate quality of service? The questions are many and very relevant. The “future home” is not future anymore. Just think of all devices in a house which can be connected through a home network. Laptops, telephones, printers, mobile phones, game consoles, cameras, PVRs, STBs, TV sets, MP3 players, surveillance systems, heating and ventilation systems, storage devices, HiFi systems and so on. Connecting all these devices in one network and through one access point is a very complex task. In the next chapter, we will look deeper into the home network and the residential gateway which connects the home network to the access network.

Chapter 3
Home Networking

Home networking is the collection of elements that process, manage, transport, and store information, enabling the connection and integration of multiple computing, control, monitoring, and communication devices in the home. (IEC, 2007)

As we outlined in the previous chapter, home connectivity has evolved dramatically the last years. Broadband has created new possibilities and enhanced the quality of existing Internet related services. The new generation of broadband services combining television, telephony and Internet over the same IP network has given new and complex challenges. Access networks must be upgraded in order to deliver the necessary bandwidth and quality of service. Within each household, the various devices must be connected in a satisfactory way and a controlling unit must ensure that each service is allocated its appropriate service class. This controlling unit is often referred to as a Residential Gateway (RG) or a home gateway and is located in the transition between the access network and the home network. In this chapter, we will concentrate on technology requirements for complete home network solutions. First, we will give an overview of the compound home network and then we will look into existing solutions for RGs and home network technologies.

3.1 Overview of the Compound Home Network

The complete home network consists of the physical interconnection (both wired and wireless) of devices in the home as well as the residential gateway which connects the network within the home to the access network and routes and controls all inter and intra network traffic. The RG is “the brain” in the home network and controls traffic to and from various devices. As the diversity of services delivered through the home network rises, the RG gets more and more complex tasks. The physical interconnection of our home devices might exist of various wired and wireless technologies. Combinations of Ethernet, coax, copper and for example 802.11g networks might be the reality in a home network. Only one access network is normally connected to the RG, but end devices within the home network may connect directly to additional access networks (e.g. a STB connected to a satellite or terrestrial network). (HGI, 2006) Many factors play a role when deciding on what access technologies and home network infrastructures to use. Geographic location, building density, type and age of building and the number residents are some of the factors. (Hartog, Jong, Balm, & Kwaaitaal, 2004)

We will now look deeper into the home network and study appropriate infrastructures and RG solutions. Future and present services presented in the previous chapter form

the basis of the requirements we will try to cover in the home network solution. IPTV will be “the big bandwidth eater” and put strict bounds on delay and jitter. But, before we look into the specific and more technical requirements to home networks, we will look at some use cases of the compound home network.

3.1.1 Use Cases

In order to illustrate the usage and the requirements of the future home network, we have defined some use cases and scenarios. We will use a typical family with two parents and two children as a basis for our use cases. The family named Nielsen lives in a two floor house with a terrace, a small garden and a garage. They have a broadband connection purchased from a network operator that delivers and controls the RG and operates the access network. The Nielsen family has several Consumer Electronics (CE), mobile- and computer -devices in their home. An illustration of Nielsen’s house and some of their devices are shown in Figure 3.1. Common devices in home networks are listed on the next page.

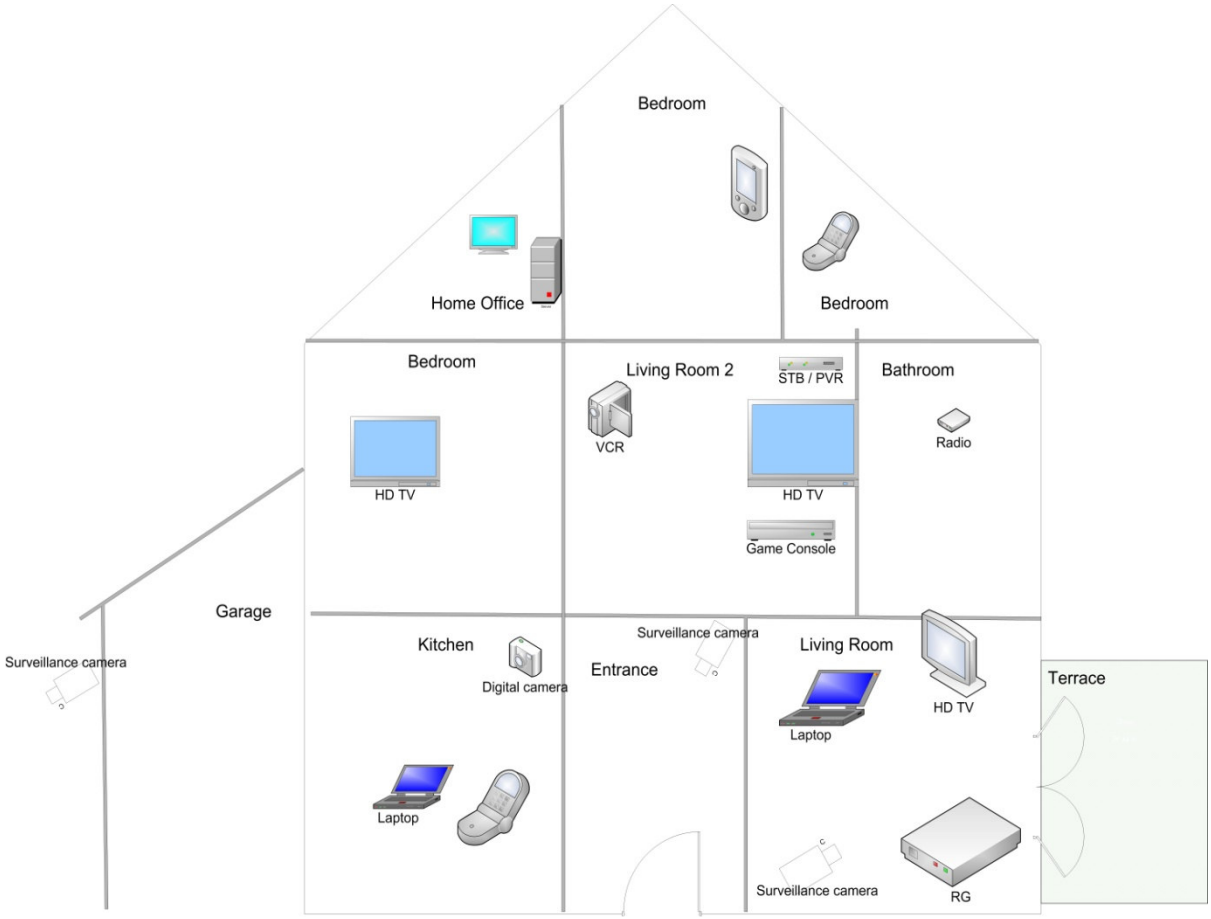

Figure 3.1: Illustration of Nielsen's house and the devices they are using in the various rooms.

Possible devices in a home network:
Personal computers
TV-sets
Set-top boxes
Personal Video Recorder (PVR)
Telephones
Game consoles
Hi-fi and radios
Storage devices
Printers
Personal Digital Assistants (PDA)
Mobile phones
Digital cameras
Surveillance cameras
Mp3 players

Scenario 1:
Mr. and Mrs. Nielsen want to watch a movie on a peaceful Sunday night. They turn on their 50" HD ready LCD screen which is connected to a STB. The STB has both a standard remote control and a computer like cordless keyboard for more advanced operation. Mrs. Nielsen remembers that she read about an interesting film on the web the other day, but does not remember the name. Hence, she uses the web browser installed on the STB to connect to the Internet and look up the film review. Mr. Nielsen reads the film review quickly on the LCD screen and they agree to watch it. They enter the VoD menu in the home network user interface and stream the film in full HD resolution. During the film, Mr. Nielsen's cellular phone starts ringing. The home network detects that Mr. Nielsen is located in the same room as the LCD display, and displays the caller ID on the top corner of the screen. The film automatically pauses while the phone rings. Mr. Nielsen chooses to reject the call with the TV remote control and the film automatically starts playing again. The expense for the movie is automatically added to their monthly bill from the network operator.

Scenario 2:
Nielsen's son Michael is watching his favourite TV program in HD resolution on the LCD screen in the 1'st floor living room. Suddenly he recalls an appointment with his friends. He has to leave, but he does not want to postpone his favourite program. Hence, he instructs the home network to continue displaying the program on his PDA which he can bring with him. The home network has already detected the PDA and adjusts the service class of the TV program to fit this device. Then, Michael leaves home and gets on the bus, watching the program all along. The home network detects that Michael is leaving the home and another available network which Michael has access to takes over the session.

Scenario 3:
The Nielsen family has left for vacation in the winter holiday. Before they left, they used the home network's UI to activate the surveillance system and turn down the heating in the home. Mr. Nielsen has programmed the home network to alert him on his cellular phone if any sensors or cameras detect intrusions. During the vacation, he wants to check that everything is ok in the house. He logs onto the home network from his laptop in the hotel room and selects the surveillance system in the home network UI. He is now

able to switch between the various cameras to check out the house and the surroundings. The day before returning home, Nielsen logs on to the home network again and access the heating system. From the UI, he can control the overall temperature as well as temperatures in specific rooms. He chooses to put the system into normal operation so the temperature is as usual when they return.

Scenario 4:
Mrs. Nielsen has a friend visiting and they sit on the terrace and enjoy the great weather. They talk about their trip to Milan last summer and Mrs. Nielsen discovers that she has not shown her friend the photos and video clips from the trip. Mrs. Nielsen switches on her laptop which automatically logs onto the home network. From the laptop on the terrace, she accesses their multimedia storage device located in the home office and finds the folder where the material is located. They watch the pictures and recall how fun they had on this trip. Mrs. Nielsen's friend wants a copy of some of the pictures and asks Mrs. Nielsen to upload the pictures to her PDA which is detected as a "guest" device by the home network. Mrs. Nielsen sends the relevant pictures directly from the multimedia storage device to her friends PDA.

These scenarios exemplify how users can interact with and utilize a home network solution. Some of the functionality mentioned is available with today's technology while some functions rely on the future development of home networks. We see that several devices are working together seamlessly over different network technologies.

3.2 End to End Architecture

In this section, we will illustrate how an end-to-end architecture might look like. We will shortly explain the architecture from the service end-points at the service provider to the end-devices within the home network on the other side. We use an architecture proposed by the Home Gateway Initiative as a basis for our illustration. (HGI, 2006)

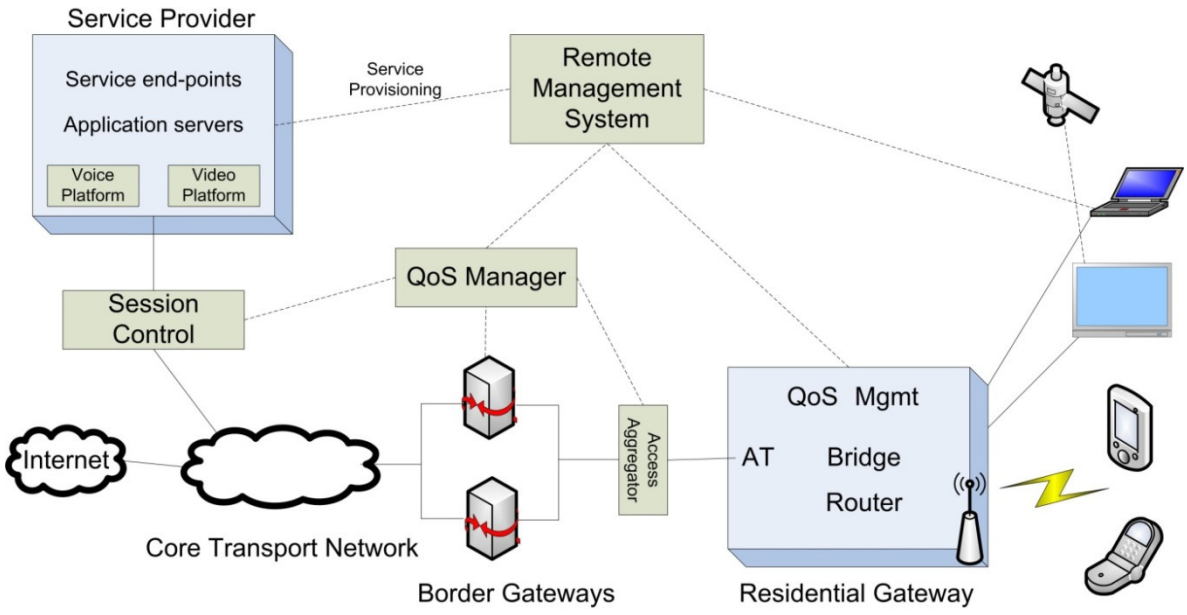

Figure 3.2: End-to-end Architectural Model (HGI, 2006)

To the left on figure 3.2, we see the service end-points. Each session is controlled such that QoS demands are satisfied. Sessions are sent through the core network and to the appropriate border gateway or Broadband Remote Access Server (BRAS) which connect the core network with the access network. An access aggregator unites sessions from various border gateways and forwards the traffic to the correct residential gateway. The RG which can operate both as a bridge and a router, see to that both external and internal traffic reaches the appropriate end-device. We see that the RG connects the access network on the left side with the home network placed on the right side in the figure. Only one access network is connected to the RG, but other access systems might connect directly to an end-device (e.g. a Satellite network to a STB). (HGI, 2006)

At all time, a single Remote Management System (RMS) controls the RG. The RMS is also used to control QoS for all services. We can see that the RMS is involved in all the phases of the end-to-end architecture. We will not go into more details on this architecture. For further information we refer to the Home Gateway Initiative. (HGI, 2006)

3.3 General Requirements to a Home Network Solution

We have now looked into the compound home network and exemplified the usage by user scenarios. An end-to-end architecture has been presented and briefly explained. We will now discuss some important properties of future home network solutions. The work done by the Home Gateway Initiative has been used as a starting point when forming the following requirements. (HGI, 2006)

3.3.1 Ease of use

It is evident that home networks are becoming more complex as we integrate more and more services and devices into the same network. To successfully combine video, voice and data over the same network, we have to introduce strict control routines for the various services. The average user has no or little understanding and knowledge of how to configure and control a complex home network. Hence, home networks must be designed accordingly. The home network solution must be simple and easy to use and demand little management from the users. Devices should be automatically detected and connected to the home network provided that certain security routines have been completed. Both the RG and the physical interconnection of the home devices must be designed with simplicity and ease of use in mind. The underlying complexity should be transparent to the users and mainly controlled by the network operator.

3.3.2 Connectivity

Connectivity is a key-word in the evolution of home networks. The number of digital devices within the home has grown radically the last years and by connecting them in one shared home network, they can communicate and share data. One of the great challenges is to physically interconnect so many devices in one common network. The home network must cover the entire home and the connection medium must satisfy the necessary QoS demands. New services like IPTV are sensitive to delay and packet loss and will not function satisfactory through today's common 802.11 b or g wireless LAN

standards. Hence, the most bandwidth and QoS demanding services might demand cabled or significantly improved wireless connection to the end devices. Mobility has become very important and an increasing share of our home devices is mobile devices. Mobile phones, PDAs, digital cameras, mp3 players and laptops are all examples of devices which could utilize a wireless home network.

The home network must allow connectivity directly between in-home devices, (i.e. not through the access network). Your laptop should for instance be able to connect directly to your PDA to share data without going through the access network. It might also be necessary to allow some end-devices to connect directly to an alternative access network. The STB must have a connection to the home network but should also be able to communicate directly to for example a terrestrial television network.

3.3.3 Quality of Service (QoS)

Today's Quality of Service based on "best-effort" is adequate for many services, but many of the future services like IPTV will demand higher levels of QoS. Live, high quality video will create stringent demands to bandwidth, delay and jitter. End-to-end QoS must be ensured to deliver satisfying IPTV services. But, QoS is costly and hence is it not desirable to offer higher QoS than the services need. QoS differentiation must therefore be applied to the network. The user-perceived QoS must be acceptable, but not so high that resources are wasted. The home network must ensure reservation of resources such that sensitive services as IPTV get the necessary QoS. The RG must be responsible for controlling the traffic and reserving necessary bandwidth in the home network. Intra-home traffic flows must be included in the QoS scheme to ensure the overall QoS demands. (Emstad, Heegaard, & Helvik, 2004)

3.3.4 Setup, operation and management

We introduced this section by pointing on "ease of use" as a very important requirement for home networks. Many factors affect the user-friendliness of a compound home network solution. In the installation phase, the physical infrastructure creates challenges. Cabled network can be achieved by using many technologies. Here is it desirable to utilize existing cables in the customer's residence to avoid work and costs by laying new cables. Easy operation of the home network is also vital to achieve customer satisfaction. A clear and easy-to-follow user interface which controls the entire home network must be emphasized in the development of home networks. Users must be able to easily add new devices to the home network at the same time as authentication and security must be ensured.

Most of the operations necessary on a home network are too complex for the average user to handle. Hence, a Remote Management System (RMS) must be used to give the network operator or a service provider access to do the necessary maintenance on the home network. The RMS is also used to ensure the necessary end-to-end QoS. Service providers might communicate with the home network's RG through the RMS and "negotiate" the necessary QoS levels. (HGI, 2006)

3.3.5 Security

The home network faces several challenges when it comes to security. The home network includes all private data as well as all communication channels within a home. Unwanted intrusions might get fatal consequences as loss of privacy, damaged or deleted data and damaged end-devices. Hence, access control to the home network must be carried out for services, devices and users. The RMS and the RG must both be authenticated to ensure secure operation. It should be possible to differentiate the access rights by defining various user classes. In that way, only selected users might be able to manage the network, while a wider group of users might use it. The RG should function as a firewall and hide the end-devices for the outside network. This will prevent direct attacks towards the end-devices. (Stallings, 2005)

We will not go deeper into the security issues with home networks in this section, but rather mention its importance. Security must be emphasized, but it must be done in a way that keeps the system user-friendly. Many include security in the concept of QoS, but we have chosen to mention it separately to stress its importance.

3.4 The Residential Gateway

The residential gateway (RG), also called the home gateway, refers to the gateway between the access network and the home network. The term is not strictly defined and is used for many different devices. Traditionally, ADSL modems, set-top boxes and home telephony switches have functioned as RGs. Today, we see that some convergence will take place and the RG will be the central and controlling unit in the future home network. The next generation of broadband services has created new sets of requirements for the RG (HGI, 2006):

- *The need to manage the Home Gateway, and to a lesser extent, the home network and the devices beyond the Home Gateway*
- *Allowing the right device or application to connect to the right service platform with the right service class / Quality of Service*
- *Unifying device capabilities in order to offer customers a better "integrated home environment".*

It is no doubt that the RG will be a very central component in the home network. But, it is also very uncertain what functionality should be integrated in the RG and what functionality that rather should be placed in other network components. STBs, content servers and personal computers in the house might control some functionality within the network. In this section, we will focus on the most important functionality which should be handled by the RG. We will not go into detail of all requirements, but rather discuss the high-level architectural requirements.

Network providers normally have general architectural requirements when changing existing network topology. The Home Gateway Initiative created a separate taskforce to produce a set of high-level requirements for the new end-to-end network architecture necessary for complex home network solutions. We will quote the most important

requirements identified by this taskforce. The high-level requirements are grouped into sets and under each set we have quoted some requirements. (HGI, 2006)

The residential gateway must:

- ***Connectivity:***
  - *Allow direct connection of other access technologies to end-devices. (i.e. a STB directly connected to a satellite TV network)*
  - *Simultaneous routing and bridging*
  - *Support direct connectivity between the in-home devices. (i.e. direct connection between two laptops in the home network)*
  - *Map services into the appropriate layer 2 pipe to reach the correct service edge node*
  - *Give support for multiple Broadband remote access servers (BRAS)*
- ***QoS***
  - *Include intra-home flows as part of the QoS scheme*
  - *Support downstream QoS, upstream QoS, and prioritizing intra-home traffic with respect to Access Network traffic*
  - *Support the QoS remarking of LAN-side traffic*
- ***Management and OAM***
  - *Single WAN-side management entity at any one time. The end devices may or may not be managed by the RG Remote Management Server. If they are managed separately (at the same time), there may be an impact on some services.*
  - *WAN-side IP addresses may be allocated by more than one entity*
  - *Split between the WAN-side network management system and user management access (for policy input and status reporting)*
  - *Data model that allows for different access technologies*
  - *Manage end-devices as well as the HG itself*
  - *OAM functionality reactive, i.e. normally off*
- ***Encapsulations and session support***
  - *Terminate, originate and transparently pass PPP sessions*
  - *Support both PPP encapsulated traffic and non-PPP encapsulated traffic*
  - *Trigger PPP sessions on the basis of LAN-side activity*
- ***IP Addressing***
  - *Support PPP and DHCP based IP address allocation*
  - *Support end-devices which have a static, public IP address*
  - *Different IP address schemes and subnets on the same physical LAN port, and on different LAN ports*
  - *Different IP address schemes and subnets on the WAN port*
  - *Support NAT and no-NAT simultaneously*
- ***Security***
  - *Management system and RG both need to be authenticated*
  - *Support a specified (and updateable) list of Application Level Gateways*
  - *Provide a Firewall*
  - *Per service, per user and per device access control*
  - *Unique (gateway) hardware ID*
  - *Secure remote (WAN-side) access to appropriate devices (e.g. a security camera)*
  - *Different classes of user with regard to management access rights*

We will not go further into the detailed requirements regarding a RG. We believe that many RG solutions will co-exist as various access technologies, home network technologies and manufacturers will affect the further development. There are already several manufacturers competing in the RG market. The Home Gateway Initiative provides detailed requirements regarding all aspects of the RG and they are leaders within the field of RG specification. (HGI, 2006)

3.5 Home Networking Technologies

Within the area of home networking, there are many actors and various technologies available. There are several technologies both for wired and wireless networks. Which technology to pursue in home network solutions, relies on many factors. We will point out some important requirements for a home network infrastructure. (HGI, 2006)

- Installation of new cables are costly and undesired by most consumers, hence utilization of existing infrastructure is desirable where this is possible.
- The home network solution must cover the whole house and some times out-door areas that are frequently used (e.g. terraces).
- The network must have satisfying bandwidth (10s of Mbps) and low latency and packet loss.
- It must be possible to protect against unauthorized access to the network
- The home network solution must not only provide end-devices access to services offered by the access network, but also intra-home connectivity.
- Users should be able to use existing infrastructure devices as in-line technology bridges or switches and not rely on a single vendor.
- The users should not be restricted by other factors than those required by the relevant technology.
- The network should not interfere with other existing broadcasting technologies.
- The home network solution should not depend on other infrastructure devices than the RG.
- Mobility has become very important also in the home environment; hence wireless connection should be made possible in the home network.

Most homes already have cables covering certain parts of their home. Everyone has power lines within the home and almost everyone has some coverage of copper telephone lines. Many homes also have coaxial cabling for cable or terrestrial television. But, these technologies are not designed for data traffic as for instance Ethernet is. Hence, many challenges and obstacles occur when trying to utilize the older networks as data networks. We will now present various candidate technologies for a home network and point out their advantages and drawbacks.

3.5.1 Ethernet

Ethernet is by far the most used solution for interconnection of PCs and workstations. Approximately 85% of all LAN connected computers in the world use Ethernet. The term Ethernet is used for a family of LAN technologies. They are all covered by the 802.3 standard that defines the Carrier Sense Multi-Access / Collision Detection (CSMA/CD)

protocol. Ethernet is defined for various data rates and over both optical fibre and twisted-pair cables. These four data rates are currently defined (Cisco Systems2, 2007):

10 Mbps	10 Base-T Ethernet
100 Mbps	Fast Ethernet
1000 Mbps and 10 000 Mbps	Gigabit Ethernet

Table 3.1: Overview of the various data rates defined in Ethernet

Ethernet has gained such great popularity because of several reasons. It is easy to understand, implement, manage and maintain. The costs of network equipment are low and lead to low cost network implementations. Basic interfaces and switches are today available at consumer prices. Ethernet is very flexible when it comes to topology and network infrastructure. It works independent of manufacturers as long as the products are standard-compliant. Today, Gigabit Ethernet becomes more and more common in new networks. Fast Ethernet is still most widespread for home and business use, but we see that more and more network devices are ready for Gigabit Ethernet. New Gigabit ready equipment is compatible with the lower bit-rate Ethernet definitions, but the slowest link will of course limit the data rate. In a home network solution, Gigabit Ethernet would clearly be preferable. The cost difference between Fast Ethernet and Gigabit Ethernet is minimal and the bandwidth 10 times better. If we include HD quality IPTV and all intra-home traffic, throughputs higher than 100Mbps might be required. (Cisco Systems2, 2007)

Based on all these benefits, Ethernet seems very suitable for home networks. But, Ethernet has its drawbacks as well. One of the requirements for a new home network was to minimize new installations in people's homes. Ethernet will demand new cabling throughout the house which lead to high installation costs and often inconvenience for the customers. The importance of this factor is of course varying with the size, age and need for cabling in each house. A small modern apartment with cable sock support will be relatively cheap to cover with Ethernet cables compared to a large older house. How many network contact points needed is also varying from home to home. If only one stationary TV-set is present, it might be sufficient to have one network point by the TV-set since IPTV probably will be the most demanding service. The rest of the house or apartment could then cut it fine with a wireless network solution. But, these factors depend on the size of the home, the number of people present and the number of high bandwidth and QoS demanding services.

Power over Ethernet (PoE) or IEEE 802.3af is a standard which allows users to power devices via twisted pair Ethernet cabling. The power delivered with PoE is limited to 13 watts and the standard makes use of two of the four twisted pairs that are available in a standard CAT5 Ethernet cable. PoE is absolutely not a complete substitute for power cabling in a home, but can replace a separate power cable for low-powered devices. It is ideal for surveillance cameras, VoIP telephones, wireless access points and other devices dependent on both power and Ethernet connection. By using PoE, installation of new devices might be simplified and less costly. (GarrettCom, 2006)

3.5.2 Power Line Technology (PLT)

Compared to Ethernet, PLT is a relatively new technology. HomePlug Powerline Alliance is leading and well-accepted to define industry standards based on power line communications technology. HomePlug was formed in 2000 and the first industry standard, HomePlug 1.0 was released in 2001. Today, HomePlug AV is the prevailing standard. (HomePlug, 2007)

PLT utilizes the existing home power lines which originally were devised for power distribution to communicate data throughout the home. Power is distributed at 50-60 Hz, but data might be transported over the same medium at higher frequencies, even though it presents several technical challenging problems. Impedance, signal loss and channel characteristics vary due to a many different conductor types used in the networks, variations in amplitude and phase over frequency as well as network load. Interference is another great challenge with PLT. Various electronic equipment produce impulse noise that reduce the reliability of communication signals. This noise is location dependent, because of high attenuation over the power line. Despite these great technical challenges, advanced solutions using both physical and data link layer techniques have made PLT a promising solution for home networking.
The physical layer of the HomePlugAV standard operates in the frequency range of 2 – 28 MHz. This gives a physical channel rate of 200 Mbps. HomePlug AV provides both connection-oriented and connectionless services. The connection-oriented Contention Free (CF) service supports quality of service requirements as guaranteed bandwidth, latency and jitter and is based on Time Division Multiple Access (TDMA).
A connectionless, prioritized Contention based service is also provided by HomePlug AV. This service supports best-effort traffic as well as traffic that rely on prioritized quality of service. Collision Sense Multiple Access / Collision Avoidance (CSMA/CA) is used for this connectionless service. (HomePlug, 2001) and (HomePlug, 2005)

Power line technology is unique because it connects the home almost completely using existing infrastructure. The average American home has 47 connection points which can be used to deliver a HomePlug network. This heavily exceeds all other indoor cabled networks. (Melder, 2006) Consumer equipment prepared for HomePlug AV is available and new equipment from several suppliers was presented on Cebit in March 2007. Power line technology is very promising and seems very suitable for the connected home. By utilizing the power line network, people can theoretically just connect their TV-set to the power outlet to get power, TV-signals and data signals for Internet and other services. But, even though the physical rate is 200 Mbps, an effective throughput of around 50 Mbps is the maximum for the time being. This might be insufficient for the future home network. The fact that power lines are very noisy leads to very varying throughputs in the home network. This can make PLT unsuitable for some residences. The condition of the electrical wiring and equipment in each residence as well as the bandwidth demands vary a lot between each home. For homes with one or two residents, 50 Mbps might be sufficient for both inter and intra home network traffic. (HomePlug, 2005)

3.5.3 Home Phone Networking Alliance (HomePNA)

HomePNA develops home networking solutions over both existing copper phone lines and coax cables. Their latest specification, HomePNA 3.1, was in late February 2007 approved as a global multimedia home networking standard by ITU. (HomePNA / ITU, 2007) This makes HomePNA the only internationally standardized existing-wire home networking technology. The specification for HomePNA 3.1 is very young (released in November 2006) and real tests results of the standard are hard to find. (HomePNA1, 2006)

According to (HomePNA2, 2006), HomePNA 3.1 delivers a data rate as high as 320 Mbps, by using both existing phone lines and coax cables. We are not certain of the effective throughput in HomePNA 3.1 network due to the lack of real test results. We are therefore forced to rely on the information provided by HomePNA. In addition to high bandwidth, HomePNA claims to "guarantee" QoS by providing guaranteed jitter, latency and error rate for each stream.

HomePNA is utilizing existing cables in the home to deliver a high bandwidth network infrastructure. Most homes in the world have phone lines with one or several outlets in their home. The number of outlets varies a lot. Some homes might have only one or two outlets while others might have plenty. Coax wiring within homes is not as widespread as copper phone lines, but in some countries a great share of the homes has coaxial cabling (e.g. 80 % of US homes have coaxial cabling) (HomePNA2, 2006). Hence, HomePNA might be a great alternative for homes with wide coverage of phone lines and/or coaxial cabling. In the United States, AT&T recently selected HomePNA 3 as technology for in-home distribution of some of their services. (HomePNA2, 2006) But, many other countries in the world have less spread of coaxial cabling in consumer homes and might get insufficient network coverage with HomePNA.

There are several advantages by HomePNA. It is able to work over and combine two different wired technologies and they claim to deliver a bandwidth and QoS sufficient to deliver several HDTV channels simultaneously in addition to other home network services. The ability to use existing wiring within homes to deliver so high bandwidth is for the time being unique for HomePNA. But, the disadvantage by HomePNA is that residences must have a well developed phone line and/or coaxial network within the home. Many homes do not have sufficient phone and coaxial wiring to cover their residences. For them, HomePNA might not be a good alternative.

3.5.4 Multimedia over Coax Alliance (MOCA)

MOCA is an open industry driven initiative for home networking using existing coaxial cabling. A data rate of up to 270 Mbps is possible and field tests in 250 US homes shown that over 110 Mbps net throughput was available in 97 % of the outlets. MOCA has many of the same characteristics as HomePNA. It seems to deliver acceptable bandwidth and also claims to "guarantee" full QoS. But, MOCA is only an alternative for homes covered with coaxial cabling. They do not support phone line connectivity as HomePNA and are therefore relevant for a smaller segment of the market. But for markets as for example USA, where the spread of coaxial technology is high, MOCA might be an actual alternative for the future home network. (MoCA, 2007)

3.5.5 The 802.11 wireless LAN standards

Wireless Local Area Networks (WLAN) within homes and enterprises have become very common. The family of the IEEE 802.11 standards is widely used all over the world. WLAN uses a "spread-spectrum" technology which spreads a radio signal out over a wide range of frequencies. Spread-spectrum makes the signal become less susceptible to interference and difficult to intercept. Today, several variants of the original 802.11 standard are used. (Gast, 2005)

Overview of some of the existing wireless LAN standards: (intel, 2007)

802.11 The original WLAN standard. Supports 1 – 2 Mbps
802.11a High speed WLAN standard for the 5 GHz band. Supports 54 Mbps.
802.11b WLAN standard for the 2.4 GHz band. Supports 11 Mbps.
802.11d International roaming –automatically configures devices to meet local RF regulations.
802.11e Addresses quality of service requirements for all IEEE WLAN radio interfaces.
802.11f Defines inter-access point communications to facilitate multiple vendor-distributed WLAN networks.
802.11g Establishes an additional modulation technique (OFDM) for the 2.4 GHz band. Supports speeds up to 54 Mbps.
802.11h Defines the spectrum management of the 5 GHz band.
802.11i Addresses the current security weaknesses for both authentication and encryption protocols.
802.11n The next generation WLAN. Provides significantly higher throughput (~500Mbps) and wider range.

The 802.11 a/b/g are most common and provide adequate performance for most of today's networking applications. 802.11 a and g deliver ~54 Mbps physical throughput, but a significant portion of the available channels are used to improve the reliability of the data transmissions. Hence, the net throughput of all WiFi standards is significantly lower than the given physical throughput. Typically, a 54 Mbps physical connection will give approximately 25 Mbps when the signal strength is excellent. When the signal worsens, the throughput drops accordingly. The maximum range of today's wireless standards is approximately 90 meters without any major walls or other physical obstructions present. Within a real home environment with walls and many other obstacles, the actual range is much lower. (intel, 2007) and (Gast, 2005)

Higher throughput and better QoS will be required for many of the future home networking applications like IPTV. A wider range is also necessary to ensure sufficient throughput in the entire home and often on terraces and in gardens. Hence the next generation of wireless networks will have to satisfy these needs. We will now look at the coming, but not yet finally standardized 802.11n WLAN standard.

3.5.6 The up and coming 802.11n

The next generation 802.11 standard was announced in January 2004, but is still not finally standardized. The Draft 2.0 was approved in March 2007, but a final approval of the standard is not predicted before the middle of 2008. (IEEE, 2007)

802.11n which is the name of the new WLAN standard from IEEE, is primarily aimed at providing higher throughput than the previous standards within the 802.11 family. An actual throughput of at least 100 Mbps is expected from the new standard and this will quadruple the present throughput of the 802.11 a and b standards. The physical throughput of 802.11n might exceed 500 Mbps. (intel, 2007)

This significant increase in throughput is mainly achieved by using multiple antennas and wider bandwidth spectral channels. The technical term for using multiple antennas for both the transmitter and the receiver is multiple-input multiple-output (MIMO) or smart antenna system. MIMO improves wireless performance by utilizing multiple transmitters and receivers which lead to a more efficient use of the spectrum without sacrificing reliability. MIMO may also provide Spatial Division Multiplexing (SDM) which spatially multiplexes several independent data streams simultaneously within one spectral channel of bandwidth. This can increase the throughput significantly because the number of resolved spatial data streams increase. Each stream must have its dedicated transmitter / receiver antenna pair. This demands carefully architecture when costs shall be kept down on the same time as expected performance must be maintained. (Gast, 2005) and (Wilson, 2004)

Wide bandwidth channels with orthogonal frequency-division multiplexing (OFDM) can double the legacy bandwidth of 802.11 from 20 MHz to 40 MHz. This can more than double channel bandwidth if used properly. MIMO used in combination with wider bandwidth channels is a very powerful but still cost effective technique for increasing the throughput in 802.11n. We will not go in further detail of the technical specification of 802.11n, but further information can be found in the wireless network guide by Matthew S. Gast. (Gast, 2005).

A lot of pre-standard implementations of 802.11n products are already available in many computer electronics stores. These products rely on the Draft 1.0 and are not guaranteed to be compatible with the ratified 802.11n. However, we see that the industry is eager to produce 802.11n products which reflect a market demand.

The new 802.11n standard will hopefully deliver significantly higher bandwidths than we are used to with today's wireless technologies. If 802.11n delivers a net throughput over 100 Mbps, this technology alone might be sufficient to cover whole homes with all necessary services. But, there are still many uncertain factors. Equipment costs, actually throughput, coverage and QoS are some of the factors important to know before we can say anything for sure about 802.11n. Hopefully, we have a new finalized high-speed wireless LAN standard which can be an important contributor to the future home network within 2008.

3.6 Summary

Throughout this chapter, we have looked into some of the technical challenges facing the development of the next generation home network. The compound home network has been illustrated and exemplified by use-cases. We presented the residential gateway and the physical interconnection of devices as the main parts of a home network solution. Requirements and technical solutions have been presented. When evaluating requirements for the residential gateway, we have based our work on the solution proposed by The Home Gateway Initiative. (HGI, 2006) Various technical solutions have been discussed as candidates for in-home interconnection of devices. Both wired and wireless technologies have been considered. Requirements have been proposed and various solutions evaluated. In the following chapters, we will move from technology to business and discuss how a business model for the future home network can be designed. In chapter 6, we will further discuss both technical and commercial challenges regarding the further development of a home network solution.

Chapter 4

From Technology to Business and Revenues

We have throughout this thesis explained the shift toward a converged home network. Scenarios, technologies and requirements have been discussed. But so far, we have not touched the business issues regarding the new and converged network. Traditionally have broadcasters, telephone companies and cable companies operated separately and not been directly competitors. By the introduction of triple-play, this has changed. The borders are crossing and competition between the earlier separated businesses emerges. In the coming sections, we will look at how the traditional business models are affected by the convergence. Actors from television, telephony and Internet are all affected when their services converge. Development of triple play services including investments in infrastructure, residential gateways, STBs and home network infrastructure are huge. Who shall pay the bill and how shall Return On Investment (ROI) be ensured? Without good business models, the emerging home network solutions will doubtfully succeed. The uncertainty and challenges facing the further development of complete home network solutions are many. Technically, there are several solutions satisfying today's requirements. The main concerns are whether investments in these complex solutions will give acceptable ROI. Huge investments are necessary to deliver IPTV, VoIP and Internet connection over the same physical access line. As long as revenues and profit models are uncertain, network operators hesitate to make huge investments in their infrastructure. (McCartney, 2006)

"We have indications about costs – they will be something between frightening and astronomic. We have far less idea about prices and revenues" –Ian Pulford, (McCartney, 2006)

We will start looking briefly at how the various actors traditionally have run their business and generated revenues. Further we will look at how the market is changing and explain how convergence will affect companies involved in the triple play development.

4.1 From independent actors to a converged market

4.1.1 The Telecom Industry

For more than 100 years, telephone call service has been the mainstay for the telecom industry. Voice services through a fixed network have dominated the telecom business for decades and given good incomes for the traditional telecom companies. But the situation is changing. By 2009, it is projected that two-thirds of all callers will be mobile subscribers which will lead to declined traffic in the fixed access networks. (Nanjie1,

2006) Technically there are so many ways to enable a phone call today that the telephone no longer is regarded as a rare resource. As various alternative technologies as VoIP emerge, packet communication (IP networks) actually causes loss in revenue for overall voice service. This forces the telecom industry to generate revenue from other non-voice services. However, it is hard to compensate for the lost revenue in voice traffic with new services and operators are looking for some new kind of high profit services, without any clear target in sight. The "modern" telephone network will basically be divided into two layers: The Communication Network (CN) layer and the Service Network (SN) layer. (Nanjie1, 2006) The new telecom economy will mainly be based on building business using the SN. The traditional network has generated profits by selling minutes, bandwidth and / or the tangible asset it operates on, while the SN will generate values from selling capabilities such as digital authentication, searching, storage etc. The future home network will require a wide variety of services in addition to the physical pipeline. This might create new business opportunities for the telecom industry. (Nanjie1, 2006)

4.1.2 Cable Network Operators

The cable companies have been the initiators of the so called triple-play development. Initially their business was to sell access to packages of TV-channels through their cable network. They built their own infrastructure using coaxial cabling to the clients' homes, partially paid by the customers. The last years, many cable network operators have upgraded their infrastructure to operate bi-directional such that signals can be sent back from the customer to the operator. This is a prerequisite to be able to carry data traffic along with the TV-signals and has opened for new business opportunities and made the cable companies able to offer Internet connection and VoIP service to their existing customers. Most cable companies charge their customers a fixed price for the specific package of TV-channels and the specific bandwidth of the Internet connection. VoIP service has differentiated prices where various subscriptions exist to suit both low and high volume users. Each month, the customers have one fixed cost for their selected package plus a cost based on their telephone usage. Hence, a complete triple play service can be offered, making the telephone company redundant for in-home services. But, the dissemination of cable networks varies greatly between various countries. The US has a great spread of cable customers (almost 60 % of TV households are connected to a cable network) (NCTA, 2007) while European countries have around 40 % penetration in average. (Cable Europe, 2007) Hence, cable companies are limited by their network dissemination and infrastructure state in each country. To offer broadband, the cable connection must be bi-directional. This is a costly upgrade that the cable network operators do gradually. So, even if you have television through a cable company today, you are not guaranteed that broadband is available through the coax. But, the cable network operators have started their development of triple-play and many companies offer complete solutions to many of their customers. What the cable companies have not yet addressed is the development of complete home network solutions. They deliver the services to the house, but do not bother how their customers connect their in-home devices. There is no central unit that controls the devices and aggregates all services. Hence, the triple play package offered by the cable companies still lacks important functionality to be called a complete home network solution. (Cisco Systems3, 2006)

4.1.3 Broadcasters

Within television, we have a wide variety of actors with different distribution networks, business models and ways of generating revenues. Several national broadcasters use terrestrial networks to distribute their signals. These TV-channels have traditionally been subsidized through a state broadcasting system or financed by commercials. With the transition to digital terrestrial networks, broadcasts can be coded, and pay-TV can be distributed along with the "open" broadcasts. Cable and satellite network operators offer a wide variety of TV-channels through various packages. The customers usually pay a fixed price per month for the specific package. The TV-channels within the packages can be pure pay-TV channels or partially financed by commercials. All TV-channels buy a certain share of their content from the content industry. All together, we have several actors within the television business; broadcasters and TV-programmers, viewers, the advertisement industry and the content industry. The coming convergence of television and Internet leads to even more actors and expand the existing business models. By doing television interactive, it will be possible for users to participate in and control broadcasts, commercials, movies and more. This will definitely change the TV as medium and render new business opportunities. The already complex business models for television will become even more complex as television and Internet converges and the TV becomes interactive. E-learning, shopping, personalized commercials, VoD, networked PVR and web services are some of the new opportunities which will affect current television business models. (Moormann, 2006)

4.1.4 Convergence leads to changes

The rapid development of Internet and IP based services has lead to dramatic changes in the telecommunication industry. As we outlined in section 2.1, the number of broadband subscribers increases rapidly. We also mentioned that this development has led to many new services which increase people's demand for bandwidth. As the hunger for bandwidth is constantly increasing, consumer prices are decreasing due to high competition. This has resulted in a critical situation for many network operators. Because of the huge growth in data traffic, the network operators are forced to constantly invest in new and advanced network elements. When consumer prices continue to fall, actions must be made to still ensure revenue. (PacketFront, 2007)
At the same time as network operators are challenged with decreased income from voice traffic and a rapidly increasing bandwidth demand, triple-play has emerged as a packet solution in the industry. Delivery of telephony, television and Internet over the same physical access line has become a great challenge for the telecom operators. The cable network operators have already offered such solutions for some time and lead the race against the telephone companies when it comes to realization of triple-play.

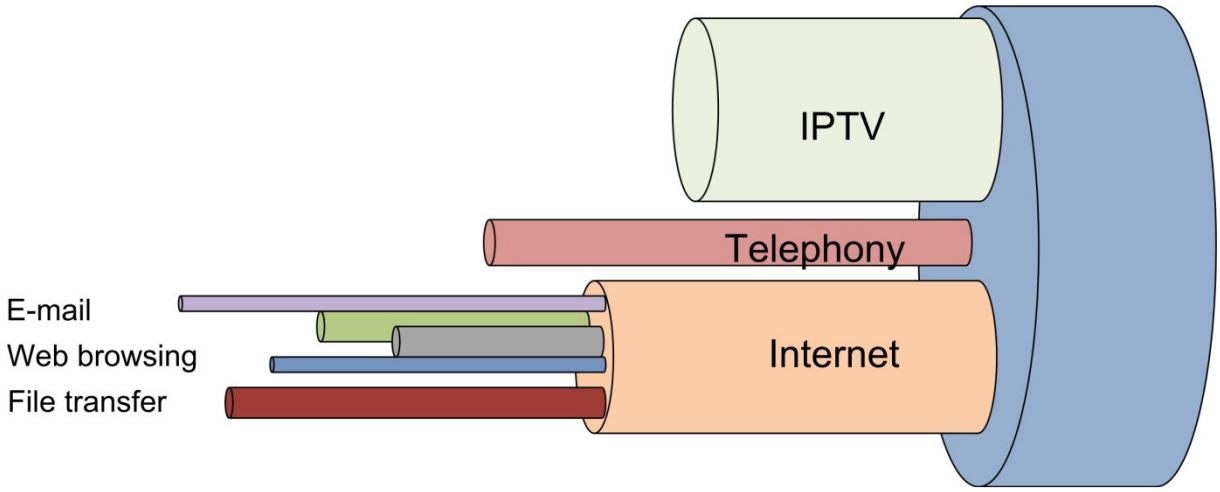

Figure 4.1: Illustration of triple-play, where telephony, Internet and television are distributed over the same physical access line. (PacketFront, 2007)

The design of a triple-play network is not a trivial task. Severe technical requirements on security and quality make the development very complex. Beside technical challenges, cooperation between network operators, service providers, content producers, broadcasters and other actual operators is very central in the development and operation of triple-play. How shall revenues and costs be shared among the various operators? How can network operators be ensured a satisfying return on their tremendous investments in triple-play solutions? The questions are many and the uncertainty of the market and the revenues is high. (PacketFront, 2007)

Today, most network operators use flat-rate pricing and more complex services and increased traffic in the network does not increase the network operator's revenues. Often, the service providers make profit using the Internet, but without paying network operators for the traffic to their customers. Major service providers as Google, iTunes and YouTube use the Internet to distribute their services with minimal costs. Services become more and more demanding, increasing the capital expenditures (CAPEX)[1] and operating expenditures (OPEX)[2] for the network operators without generating the necessary ROI. Network operators have to do actions to ensure revenues. Liu Nanjie discusses these challenges fronting telecom operators in (Nanjie1, 2006) if further information is desired.

4.2 Developing a business model

4.2.1 Our starting point

As we have mentioned in the previous sections, many actors are involved in the development of home network solutions which include television, Internet and telephone services. Existing business models will no longer be useful as the markets converge. Hence, we have to create totally new models which combine parts from the earlier independent actors' business models. The business models of

[1] The capital invested in new resources as property, equipment etc.
[2] The annual costs associated with the network operator's asset maintenance and operation.

telecommunication, Internet and television are already complex when regarded separately. Naturally, the complexity and uncertainty will become even greater when they are combined into one model.

There will be several actors with different starting points offering home network solutions. Hence, we cannot create a business model that will fit all actors perfectly. But, we will try to make a general model which can have some validity for telecom operators as well as cable companies and fibre network operators. The basis and common feature for the type of company we will look at, is that the company is a network operator which controls a network infrastructure. We will try to design a business model for such an operator who wants to offer complete home network solutions for their customers.
In addition to the network operator which will be the main actor in our business model, partners from the ocean of various service providers will be present in the business model. Actors representing broadcasters, the content and advertising industry, equipment manufacturers as well as installation companies will have different influence on the business model development.

4.2.2 Defining a business model

To clarify what we want to obtain by creating a business model, we will try to explain what a business model really is and why it is so important. Alexander Osterwalder uses this definition for a business model:

"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing an delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams." (Osterwalder, 2004)

A business model is a representation of how a company buys and sells goods and services and earns money. What a company offers, to whom it offers its goods/services and how it can accomplish it are questions answered in a business model.
Rapid technological change and globalization have actually led to increased complexity and uncertainty for today's businesses. The intense use of ICT has increased global competition and increased the choices of how to configure a business radically. This makes the concept of a business model even more important. A good business model will help the company to manage uncertainty which is one of the most important challenges facing today's managers. Representing a complex business idea in a structured, simplified and understandable way is of great importance when a company (or often several companies in partnership) shall realize a new business.

4.2.3 The business model's role within the company

The business model shall connect various parts of an organization and give a clear communication of concepts and understandings between the various parties. In (Osterwalder, 2004), the author places the business model as a conceptual link within a triangle formed of business strategy, business organization and ICT. (Figure 4.2)

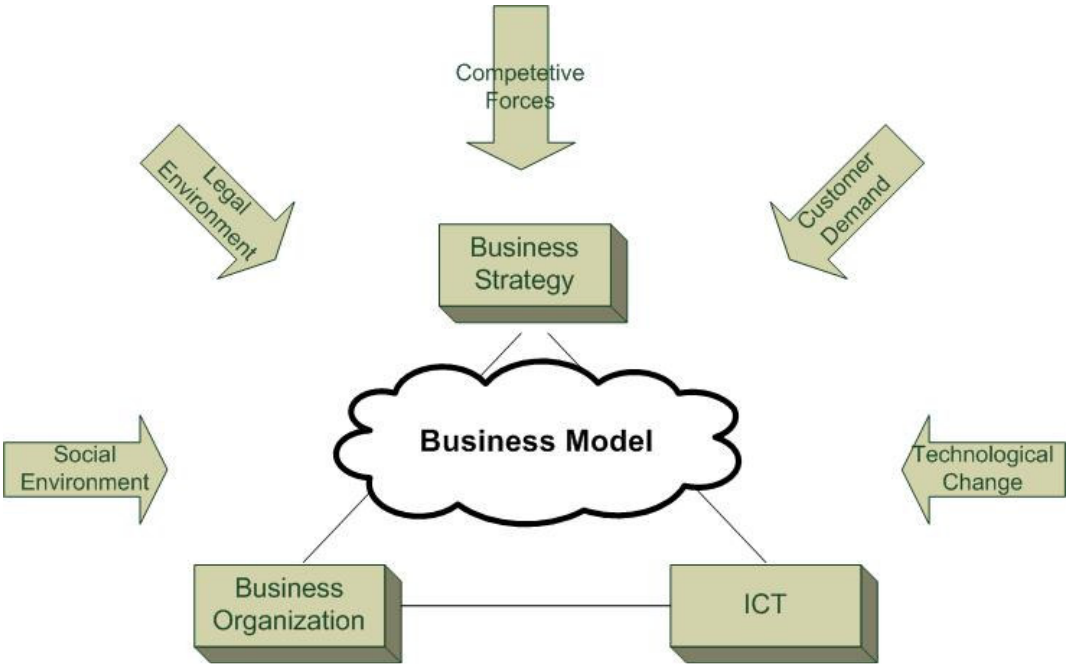

Figure 4.2: Illustration of a business model's situation in a company. The triangle illustrates internal divisions connected by the business model in the centre. The surrounding arrows represent external forces that continually affect the company. (Osterwalder, 2004)

In Figure 4.2, we see that business strategy, business organization and ICT represent different groups within a company. Each of these groups looks at the firm from different angles and represents various groups of employees with different backgrounds and views. The business people plot the course for the company and define objectives and goals, while business process and ICT designers must understand these objectives and transform them into something concrete. To ensure that the objectives and goals defined by the managers get correctly implemented, clear communication of concepts and a common understanding among the involved parties is a must. A business model helps create this shared understanding of how the company shall generate revenue and facilitate communication between people and systems within the company.
External forces are of course also decisive when starting and operating a company. We have included some of these forces in our illustration in Figure 4.2. Competition, legal, social or technological change and changes in customer demand are all factors which affect a company's success. A company must respond to external forces and business models should therefore be designed with this in mind. By making business models flexible, companies can react faster to changes in the business environment. This might be crucial for today's businesses which face a continually changing market. (Osterwalder, 2004)

4.3 Business model ontology

Before starting the design of a business model, we must choose an ontology that allows us to accurately describe the business model of a company. We have selected the ontology presented in (Osterwalder, 2004) as a starting point for our business model. This ontology identifies four main areas which are further divided into a set of totally

nine building blocks. Together, these building blocks form a business model. We will shortly explain how the ontology divide the business model into elements, sub-elements and belonging attributes. In the next chapter, we will present each of the elements, explain what they describe and relate them to our home network solution.
In Table 4.1, we see an overview of all nine main elements or building blocks which form the business model. Each building block belongs to one of the four main groups or pillars visible in the first column.

For each of the nine main elements, there exist sub-elements which split up the main element into smaller parts. Both the main elements and the sub-elements have attributes as name, description and additional element specific attributes which give additional information to the element. All sub-elements and attributes are explained when we treat each building block of the business model in the next chapter.

Pillar	Building block	Description
Product	**Value Proposition**	A Value Proposition is an overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	**Target Customer**	The Target Customer is a segment of customers a company wants to offer value to.
	Distribution Channel	A Distribution Channel is a means of getting in touch with the customer.
	Relationship	The Relationship describes the kind of link a company establishes between itself and the customer.
Infrastructure Management	**Value Configuration**	The Value Configuration describes the arrangement of activities and resources that are necessary to create value for the customer.
	Capability	A Capability is the ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.
	Partnership	A Partnership is a voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.
Financial Aspects	**Cost Structure**	The Cost Structure is the representation of money of all the means employed in the business model.
	Revenue Model	The Revenue Model describes the way a company makes money through a variety of revenue flows.

Table 4.1: Overview and description of the nine building blocks that form a business model. The second column identifies which of the four main areas the building block belongs to, and the right column gives a short description of the specific building block. The table is reproduced from (Osterwalder, 2004).

To give an overview of how the building blocks are interconnected, we provide a simplified illustration in figure 4.3. We see the four main groups marked by the dotted rectangles and the building blocks are placed within the corresponding main group. When all elements have been explained in the next chapter, we will provide a complete illustration including the sub-elements.

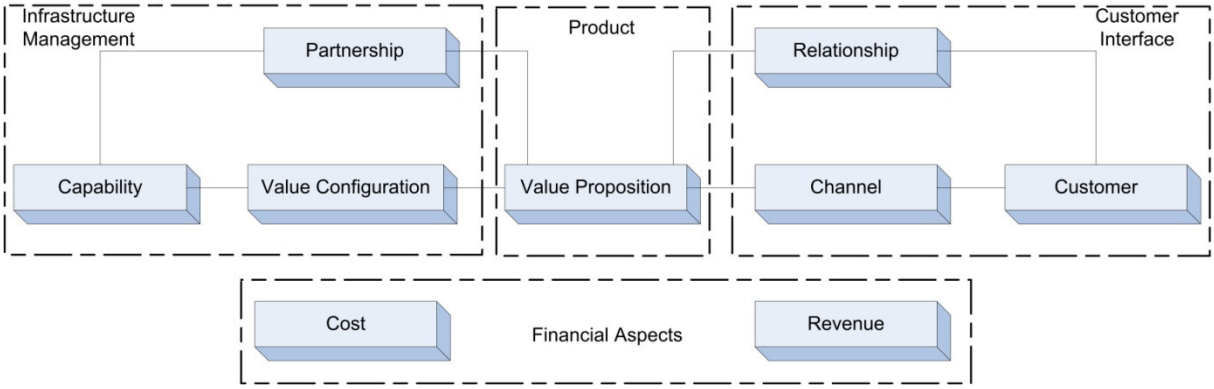

Figure 4.3: Illustration of how the main elements in a business model are linked together. The main groups are represented by dotted rectangles and the elements are placed within the respective main group.

4.4 Summary

Convergence leads to significant changes for actors in the telecom, cable and broadcasting businesses. To offer triple play, huge investments are necessary and the uncertainty of how revenues shall be generated is high. We have looked at how convergence will create challenges for the involved actors and how business models can be helpful when handling new challenges with high uncertainty. The business model ontology which we will base our model on has been presented. In the next chapter, we will use this ontology to create a general business model for a network operator entering the triple play market.

Chapter 5

The Business Model

In this chapter, we develop a business model for a company that wants to launch a home network solution with triple play. In addition to offering a physical pipeline that delivers television, Internet and telephony to a customer's residence, we will emphasize the establishment of a complete home network. We will not leave the customer after having set up the cable modem as the cable network operators do today. We will establish a solution that seamlessly integrates all customer devices and ensures cross functionality of all services on the various devices throughout the house. To establish such solutions, challenges regarding cooperation between various involved actors must be managed. Who to cooperate with, what to offer yourself and what to offer through a partner are central and crucial questions. Our business model is created from a network operator's point of view but allows for the partners involved. Because we do not have a specific company and market to consider, our business model will be more general than a real and company specific model.

To help us with the creation of a business model, we will use an ontology by Alexander Osterwalder (Osterwalder, 2004), presented in the previous chapter. Each of the four main groups will be treated in turn and all elements belonging to the specific group will be described. For each element, we will explain the belonging attributes and their values.

5.1 Product

The first main group we will look into is called product. This group covers all aspects of what a firm offers its customers. Not only the products and services it offers, but how it differentiates itself from competitors. Decisions as where to place oneself on the value chain, what products and market segments to focus on and what value added services to offer your customers have become more complex and complicated than before. This is mainly due to globalization and very rapidly changing technologies and markets. These new challenges have led to a trend to organize in networks and offer bundles of products and / or services. (Osterwalder, 2004) We will now look into the first building block of the business model that is the value proposition.

5.1.1 Value Proposition

A Value Proposition describes how items of value are packaged and offered to fulfil customers' needs. The items of value can be products, services and complementary services. The Value Proposition is an overall view that represents value for a specific customer segment and it describes how the company differentiates from its competitors.

An "offering" is a sub-element of the value proposition and represents a single product or service within the entire package. In our case, we have many offerings, as a home network solution exists of a wide variety of services and complex technical solutions. We will look at the most important offerings and their belonging attributes which form the Value Proposition. For each of the offerings, we will evaluate the following attributes:

Reasoning: Describes why the company thinks the offering is valuable to the customer. The following three values will be used:

- *Use*: the offering is valuable because of its usage. (e.g. watching television)
- *Risk*: the offering is valuable because it reduces risk (e.g. an alarm system)
- *Effort*: the offering is valuable because it reduces the users' effort. (e.g. remote management by the network operator)

Value Level (Customer Utility): Measuring the utility for the customer and allows a company to compare its offering towards its competitors. The following levels are used:

- *Me-too*: the offering does not differentiate itself from the competitors', but differentiation may still take place through for example lower price.
- *Innovative imitation*: the offering imitates and existing value proposition, but improves value by adding innovative elements.
- *Excellence*: value is pushed to its extreme (luxury products / services)
- *Innovation*: completely new services or products or new combinations of services / products.

Price Level: Compares the price of the offering with the other competitors' prices. The following levels are used:

- *Free*: the product / service is free and income comes through other sources. (e.g. advertising)
- *Economic*: a price that is more attractive than the competitors'. (often lower value level)
- *Market*: almost same price as most of the other competitors.
- *High-end*: upper boundary of the price scale. For luxury goods or new and innovative products / services.

Life Cycle: Describing in which of the following five stages the offering creates value.

- *Creation*: If the offering creates value in the creation process. (e.g. personalization)
- *Purchase*: If the process of purchase is streamlined and smooth and thus satisfying the customers. (e.g. simple purchase from the home network menu)
- *Use*: The value of an offering comes from its actual use. (e.g. watch a movie)
- *Renewal*: Value can be renewed or updated. (e.g. software update)
- *Transfer*: Value can be transferred after "consumption". (e.g. sell a book you have read back to the book-dealer)

We will now look at the most important offerings in turn:

Television
We will offer television as an IPTV service which gives customers the ability to choose among a wide selection of channels. Customers can choose between various pre-compositions of TV-channels or personalize their own collection. This will ensure that all customers find a solution that fits them. This regular TV-service will not differ much from other digital television services currently available and the value level will fit in as a *me-too* service. The price level of television will range from *economic* to *high-end* with the various packages and customized solutions. If we look at the life cycle, television will fit *creation*, (because customers can customize their channel selection) and *use*, because customers' primary value is to actually watch the TV channels.

Interactive Television
Through convergence of television and Internet, the television becomes interactive and viewers can participate in and send information back to the broadcaster directly from their remote control. This leads to new opportunities in the usage of television as a medium. The reasoning for this offering is mainly to reduce customers' *effort.* When services like web browsing can be operated directly from the TV-set, customers do not need to move to the computer for these services. This simplifies customers' operation. The value level of interactive television will fit in as *innovation* because it brings totally new opportunities into the TV. Interactive television will give high value to both customers and network operators. For customers the value lies in a simplified operation of TV/Internet services while network operators can generate revenues from new services and advertising. The price level of interactive television itself will be *free*, while services and functionalities provided through interactive television might be charged for. In the life cycle, this offering contributes to customer value through *use*.

Video on Demand (VoD) and Pay-per-view:
In addition to regular TV-channels, we will emphasize the development of VoD and pay-per-view services. We mean that people shall be able to see what they want, when they want. By offering a rich selection of high quality movies, news programs, sports events, music videos, concerts etc., people will be able to watch exactly what they want when it fits them. By offering TV programs such as news or live sport events independently of TV-channel subscriptions, customers can buy access to selected programs only. If you watch a couple of soccer matches per month it might be better to buy access to just these two matches instead of subscribing to one or several sports channels. This is what separates VoD and pay-per-view from PVR. To record a program with PVR, you must subscribe to the TV-channel that broadcasts the specific program. With VoD and pay-per-view, you can buy access to individual programs for a limited time period. We think that this is how people will watch TV in the future and will therefore emphasize the development of VoD and pay-per-view services. Personalization will be even more important as the amount of available content constantly grows and people get more demanding to what they want to see and when they want to see it. VoD and pay-per-view offer customers value through *use* of the service. The freedom of seeing "what you want, when you want" creates high value for customers. Customers do not need to go to the local video hire shop or download the content via their computer before watching the movie / program. We set the value level of VoD and pay-per-view as *innovative* despite the existence of these services for some time now. Most people have not used

such services and especially not directly from the TV-set. Hence, we allow us to call the services *innovative*. The price level will be *market* for the majority of the content. Regularly offers with price levels as *economy* or *free*, can be used to attract customers and make them used to the service. Within the life cycle, VoD and pay-per-view will create value in the *creation*, *purchase* and *use* stages. Since people choose exactly what they will see, they are involved in the *creation* process. The simple and comfortable way of *purchasing* access to content will clearly give added value to customers. At last, the actual *use* of the content will give customers the main value.

Networked Personalized Video Recorder (nPVR):
Many cable and satellite network operators offer their customers to buy or rent a set-top-box with PVR functionality. The PVR has a built-in hard drive and records the TV-programs the users select. This makes it possible for users to pause programs, see the program at another time and use rewind and other controls we know from video recorders. We will also offer PVR, but rather as a networked service than through end-user equipment as a STB. This will be a significantly cheaper and more flexible solution. Instead of buying costly end-user equipment, we will integrate PVR servers in the network. Users still control recording and all other functions from their remote as they would have done with a PVR enabled STB. The introduction of HDTV will lead to significantly higher demands on storage capacity. Instead of frequently replacing all customers' PVRs, we can simply add more storage capacity in our PVR servers to face the increased demands. Customers gain value of this service through *use*. Users can see programs as it fits them and pause an ongoing program if necessary. This is the modern video recorder and can be categorized as an *innovative imitation*. The price level of our networked PVR will be *economic* compared to PVR through customer end devices, because of the cost savings. In the value life cycle, a PVR service will create value in the creation and use stages. Customers can control the recorder themselves and hence personalize their viewing habits. PVR can be seen as a step toward VoD. When all content is available through VoD, PVR will be redundant.

Telephony:
Telephony will be offered as a VoIP service that has guaranteed quality constraints. The value for the customers is through the direct *use* of the service which functions in the same way as traditional telephony. The value level of a VoIP service is *me-too*, because the service does not differentiate from the competitors. The price level will be *economy* toward POTS and *market* toward other VoIP actors. VoIP will only give added value in the *use* stage in the life cycle.

Internet:
Internet will be offered as a "best-effort" service in the same way as it is offered to broadband customers today. The value of Internet will be through *use* and it will not differentiate significantly from the competitors Internet offers. Hence, the offering is classified as *me-too* on the value level list. The price level will be between *economy* and *market* depending on what kind of competitors you compare to. Within the life cycle, Internet will give value through the *use* stage.

Special quality guarantees (luxury services):
Many customers are willing to pay extra for special services. This might be online gamers willing to pay extra to be ensured low jitter and latency. Some customers might

want a VoIP service with premium sound quality (i.e. uncompressed). Several needs like this exist within a customer group. By offering these customers special services, we will make more profit at the same time as the customers are pleased. Such offerings will be valuable through *use*. The value level of such "luxury" services will typically be *excellence*. It is not meant for "normal" customers, but for those with special needs or for those who simply wants the best. The price level will be *high-end*, because these services are aimed at customers willing to pay a high price. In the value life cycle, these offerings create value through *use*.

The Home Network User Interface

The last offering we will mention is maybe the most important and will clearly demonstrate how our Value Proposition differentiates from existing triple play offers. The home network UI will be central in the control and operation of the entire home network. The UI can be compared with an advanced and significantly upgraded Electronic Program Guide (EPG) as used for digital television and explained in section 2.3.5. The home network UI will be available from all TV-sets and computers, as well as PDAs and advanced cellular phones connected to the home network. The UI shall provide the users simple and easy to follow operation of services and devices within the home network. Services as nPVR, VoD, pay-per-view, web-browsing and e-mail are easily accessed and controlled through the UI. Access to other in-home devices as computers, central storage devices, telephones and so on is also easily carried out through the UI. It will function as an operations centre for the entire home network. Customer support can be ordered directly from the UI. When problems occur, the network operator can automatically or on request remotely control the home network and solve the problems.

Ease of operation increase customer satisfaction and their willingness to try new services. Hence is this user interface very central in our value proposition. The UI will be the portal of the "connected home" and it will give value to the customers through *use* and reduction of *efforts*. This way of connecting the home is innovative and hence, the value level of the home network UI should be graded as *innovation*. The UI is a part of the total home network solution and does not contribute to any additional costs. Hence, the price level of the home network UI itself is *free*. Within the value life cycle, the UI contributes to almost all stages. *Creation* is present, because content can be ordered and combined from within the UI. *Purchase* of additional services and products can easily be carried out through advertisements and links in the UI. Value is of course also created through *use* of the UI to control devices and services. *Renewal* is present through updates of the home network software and additional services or devices added to the system.

In addition to these main services, customers can add services and equipment according to their wishes. Examples of additional services can be alarm and surveillance systems, remotely heating and ventilation control, networked storage service and so on. We will not go into further detail of these additional services, but rather point out that the possibilities are many and demonstrate that the solution is forward-looking.

To give a joint overview of the core offerings in our value proposition, we provide a table where all elements and attributes of the various offerings are collected:

	Television	**Interactive Television**	**VoD, pay-per-view**	**Networked PVR**	**Telephony**	**Internet**	**Luxury services**	**The Home Network UI**
Description	Customers can choose between various packages of TV channels or customize their own collection.	TV is made interactive through the TV/Internet convergence. This creates new opportunities and simplifies many operations.	Customers can by access to different content when they want to watch it. This personalizes the television service.	Customers can record and play back programs from TV-channels they subscribe to. Gives freedom and a customized viewing experience.	VoIP service with guaranteed QoS.	Regular best-effort Internet connection.	Offering special quality guarantees for services. Aimed at a limited number of customers.	The heart of the home network configuration and operation with ease of use as the main goal. Shall increase customer satisfaction.
Reasoning	{use}	{effort}	{use}	{use}	{use}	{use}	{use}	{use, effort}
Value Level	{me-too}	{innovation }	{innovation}	{innovative imitation}	{me-too}	{me-too}	{excellence}	{innovation}
Price Level	{economy, market, high-end}	{free}	{market} (+ offerings)	{economy}	{economy, market}	{economy, market}	{high-end}	{free}
Value Life Cycle	{creation, use}	{use}	{creation, purchase, use}	{creation, use}	{use}	{use}	{use}	{creation, purchase, use, renewal}

Table 5.1: The core offerings in the Value Proposition. A short description and the attribute values are indicated in the overview.

From the main offerings discussed we can create our aggregated Value Proposition:

We shall offer customers a complete home network solution that makes it possible to deliver differentiated services as television, telephony and Internet over the same access and in-home network. Our solution will be differentiated from existing offerings by the following:

- We deliver all necessary communication and information services through one single network.
- Our home network solution connects the entire home physically with wiring and WiFi solutions as well as operational through a home network user interface that integrates all services and in-home devices.
- Many new and improved services will be available:
    - Interactive television
    - Networked PVR
    - Video on Demand
    - Personalized television, pay-per-view
    - Guaranteed QoS agreements for selected services
    - Improved quality through digital television and possibility for HDTV
    - Alarm and surveillance through the home network
    - Networked storage and backup service
- We ensure user friendliness and ease of use through a home network user interface where all services and standard settings can be controlled. Besides this, the network operator will be able to remotely control more advanced settings and help users when necessary.
- By gathering all services at one network operator, customers obtain advantages through one joint customer support for all services, one bill and predictable expenditures.
- Our home network solution is future-oriented and can be regarded as an investment for the residences.

5.2 Customer Interface

The second of the four main pillars in our business model is the Customer Interface which covers all customer related aspects. It consists of the three building blocks: Target Customer, Channel and Relationship which all will be explained in more detail. The Customer Interface describes how and to whom the company delivers its Value Proposition.

5.2.1 Target Customer

The second building block in our business model is the Target Customer. It defines a segment of customers which a company wants to address. The segmentation of customers can be very general (i.e. business / private customers) or more specific (i.e. males between 25-30 years). The Target Customer element is built up of several criterions which are sub-elements to the main element. We will now try to define our Target Customer by identifying several criterions.

In our case, it is difficult to give a very specific segmentation of the Target Customer. We deliver a home network solution and all people responsible for a household are potential customers. One prerequisite is that the household is located in a geographical area where an access technology satisfying the desired services is available. But, even if all households with a satisfactory access line are potential customers, there is no doubt that some groups of people are more engaged in new technology and more willing to stake on new solutions. Hence we can try to address these groups to find a more specific description of the Target Customer. Younger people are generally more open for changes and new solutions. Men are often more interested in new technology than women. Older people need more time and conviction to change their habits and choices. Beside these human considerations, we have several technical aspects related to where it is most profitable to deploy new network infrastructure. Generally, it is more profitable to invest in new infrastructure where the density of the population is high. By investing in new network infrastructure in dense populated areas, the network operator can cover more people per investment. This is an important aspect when revenue and Return On Investment (ROI) shall be ensured.

By adding up these criterions, we end up with the following characteristics of the Target Customer:

- Person(s) with responsibility for a household.
- Relatively young grown up (about 20-45 years).
- Men are more attracted to new technical solutions; hence the majority of target customers are men.
- The household is located in a dense populated / urban area.

These characteristics are by no means absolute and many customers will fall outside these characteristics. But strategically, marketing should have the main focus on people fitting these characteristics, especially in the early phase. When the solution gets more known in the market and a considerable share of the Target Customers has become customers, a shift toward other customer segments might be more profitable.

We have so far focused on new customers (i.e. customers that not have started using our home network solution). But, after sales of services and content is very central in our business model. The group of people using a home network solution is usually larger than the number of people deciding to subscribe to the same solution. As an example we can think of a family with two parents and two children. The parents will be the main decision-makers when it comes to the decision of subscribing to the home network solution or not. But, if the decision already is taken and the family is subscribing, the children might be an equally important customer group as the parents. Children and teenagers quickly catch up with new technical solutions and can often be the most active users of for example a home network solution. Hence, we shall focus on a wider customer segment when marketing after sale material. Movies, sports events, games and other multimedia services are often frequently used by younger people and should therefore be marketed for this group as well.

We have now mentioned which customer segment to focus on in both the initial phase and in the after sales phase. But, how shall our Value Proposition be delivered to the Target Customer? The next building block in our business model treats this question.

5.2.2 Channel

The third building block is the distribution Channel which describes how a company delivers the Value Proposition to a Target Customer segment. The Channel element describes how a company gets in touch with its customers. A Channel is an aggregated view of how a company reaches its customers and is built up of several Links. A Link can be defined as a part of a Channel and describes a specific channel role. We will now look at the Links actual for our business model and study each Link's attributes.

A Link inherits the attributes from the Offering element in section 5.1.1. In addition to the inherited attributes, the attribute Customer Buying Cycle is added (displayed in Figure 5.1). This attribute can take four values that tell us which one of the functions of the customer buying cycle a channel Link fulfils. The possible attribute values are:

- *Awareness*: the phase where the company tries to get the customers' attention. The company wants to attract customers to evaluate the Value Proposition. The company wants to get known in the market.
- *Evaluation*: The phase where customer needs and the company's Value Proposition shall be matched. The company tries to inform, advice and give the customer a chance to test the Value Proposition.
- *Purchase*: The customer has already decided to buy the product and in this phase the transaction process shall be improved. The purchase and fulfilment shall be convenient and tools like order tracking can be used to create additional value for the customers.
- *After sales*: When the purchase is fulfilled, the phase of after sales takes over. The company shall provide additional value through sales of extra services, content and provide users with good customer service.

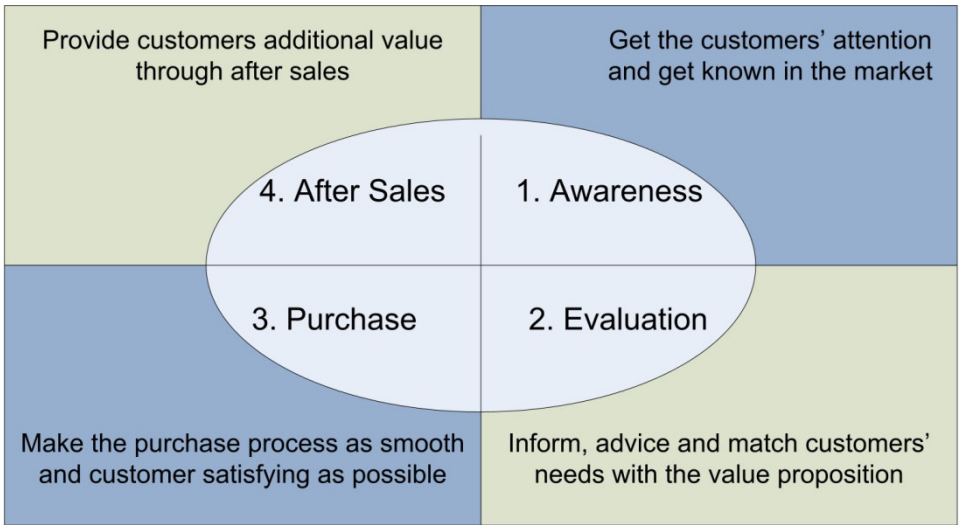

Figure 5.1: The Customer Buying Cycle illustrating the phases of interaction between a company and their customers. (Osterwalder, 2004)

Reasoning which is inherited from Offering has the same values as it had in section 5.1.1. The Link can (but does not have to) contribute to value creation in the same way as an offering. The attributes Value Level and Price Level are inherited from Offering if the Link is also a part of the Value Proposition.

We will now look at the Links relevant for creating a Channel in our business model.

Company homepage:
The company homepage is a very central Link for customer contact. Most people today are familiar with using the web as a source for information and as a way of ordering services and products. A company homepage is therefore very important for spreading information, selling services and giving customer support. The company homepage can contribute to value creation through *use* and by reducing customer *effort* by offering smooth and streamlined processes for evaluation, purchase and after sales. A homepage covers several phases in the customer buying cycle. It is maybe not directly involved in the awareness phase, since people need to know something of the company to get to the homepage. But, it is certainly very important in all the following phases; *evaluation*, *purchase* and *after sale*. The homepage must provide clear and useful information of what the company offers to the customers. The Value Proposition must be communicated clearly and crisply so that customers realize what utility they get with the home network solution and all the services offered. A test version of the home network menu which illustrates how the system works should be available. The objective is to match customers' needs with the Value Proposition and lead them to the step of purchase. In the purchase phase, the homepage must lead the customer smoothly through the process and provide necessary information to fulfil the operation. The customer should preferably feel satisfied when the process has finished. The after sales process represents its own little customer buying cycle. The homepage shall make existing customers aware of all possible extensions, extra services and content available with their home network solution. Then customers should be led through the evaluation process and to the step of purchase. In this way, the customer shall be led around and around in the customer buying cycle.

Telephone support / customer contact:
For customers not familiar with Internet, a customer telephone contact should be available. The telephone contact should provide the customer with all necessary information and preferably lead it through the same steps as described for the company homepage. The telephone support is also very important to provide existing customers with assistance when they need it. The telephone support creates value for customers through *use*. By using the telephone support people can become customers and existing customers can solve problems and buy additional services. This will contribute to added value for the customers. In the customer buying cycle, the telephone contact is equivalent to the company homepage. It is useful in the *evaluation*, *purchase* and *after sales* phases.

Electronics store:
By using electronic stores as an intermediary, we can reach even more people and provide a location for physical demonstration of our solution. This Link provides value for the customers through *use* (seeing the solution demonstrated) and through reduced *risk*. Many people feel more secure when they get a solution presented directly from another person. Hence, face to face interaction along with a demonstration of the home network solution might intercept those customers who hesitate and need conviction. The stores can present the solution when selling device like flat screen TVs, computers and other central devices in the home network. The store can be useful in all phases of the customer buying cycle. They can make customers *aware* of the solution, guide them through the *evaluation* by demonstration, fulfil the *purchase* directly from the store and perform *after sales* to existing customers by selling for instance an alarm service along with camera equipment and sensors.

Advertising:
To get customers attention, advertising is a must. It is no help in a well developed homepage if nobody knows about it. Advertising is the most important source for creating *awareness*. Advertising should mainly be focused toward the Target Customer and the choice of medium should be selected thereafter. Television, Internet, newspapers, magazines, cinemas, radio, posters and flyers are possible ways of advertising. Partners can be important intermediates, helping promoting the solution through their channels.

The Home Network User Interface:
The home network UI which is a part of the Value Proposition and explained in section 5.1.1 can also function as a Link. For existing customers, the UI will be a frequently used portal and will therefore be a very good way of offering *after sales* and customer support. Advertisement of own products and services can be displayed on certain places in the portal providing *awareness*. Further can information and assistance help *evaluating* specific products and services and finally interested customers will be guided through the process of *purchase* directly from the home network user interface. Besides being a remedy for after sales, the UI is very useful in providing customer support. Customers should be able to register problems and the remote management system should automatically do the necessary actions to solve them.

Exhibitions and shows:
Our Value Proposition might need a demonstration to convince some people. This can be achieved through exhibitions and shows. This Link will have similar characteristics as electronics stores and value can be created through *use* and reduced *risk.* Within the customer buying cycle, we can make *awareness*, help people through the *evaluation* process by demonstrations and rich information, help them fulfil the *purchase* and perform *after sales* by promoting extra services and products.

Housing cooperatives and contractors:
The last Links we will present are housing cooperatives and contractors. Housing cooperatives represents a joint group of people and by selling our solution to such groups we will increase the density of our customers which is profitable when it comes to infrastructure development. In the same way, contractors which are responsible for new constructions can include the home network infrastructure in each residence and prepare for use of the solution. In this way, the establishment cost is reduced considerably and it might be regarded as an increase in value for each residence as it is prepared for future communication solutions. Housing cooperatives must be provided with the necessary information and given a good offer which is communicated to all the residents. The leader(s) of the housing cooperative will function as an intermediate providing *awareness*, *evaluation* and a possibility of joint *purchase* of the solution. The contractor will also be an intermediary which prepare for our solution with an integrated home network and offers the solution at low establishment costs.

We have mentioned several Links which together create a Channel towards our customers. The number of Links used for a specific company is dependent on partnerships and marketing budgets. Advertising is very expensive and resources for this might be limited, especially in an initial phase where the costs are very high. Hence, more detailed decisions regarding how much and where to advertise must be evaluated by the specific network operator. In table 5.2, we provide an overview of all the mentioned Links.

	Homepage	**Telephone**	**Store**	**Advertising**	**Home network UI**	**Exhibitions**	**Cooperatives and contractors**
Description	The company homepage is very central because people use the web to look for information and to buy products and services.	Telephone support necessary for people without Internet or not familiar using it.	Electronics stores can function as intermediaries promoting and selling our solution. Important for critical customers who need demonstration	Advertising through various medias aimed at the target customer.	The UI is a frequently used portal and can function as an important Link toward existing customers	Demonstrations of the solution can be performed at exhibitions and shows to get known in the market.	Agreements with housing cooperatives and contractors can create large and joint groups of customers.
Customer buying cycle	{evaluation, purchase, after-sale}	{evaluation, purchase, after-sale}	{awareness, evaluation, purchase, after-sale}	{awareness}	{after-sales}	{awareness, evaluation, purchase, after sales}	{awareness, evaluation, purchase}
Reasoning	{use, effort}	{use}	{use, risk}		{use, effort}	{use, risk}	{effort}

Table 5.2: Overview over the Links a network operator can use to create a Channel toward its customers.

5.2.3 Relationship

The fourth building block in our business model is called Relationship. This main element describes the relationship a company establishes with a customer through several relationship mechanisms. The Relationship is based on customer equity which is an attribute to the Relationship element.

The attribute customer equity can have the following objectives in a relationship:

- *Acquisition*: How the company shall acquire new customers.
- *Retention*: How the company shall keep its customers. How to keep customers satisfied.
- *Add on selling*: How to sell additional products and services.

We will identify our relationship mechanisms through looking at each of the stages; acquisition, retention and add on selling:

Acquisition:
We can acquire new customers through several of the Links described in the previous section. In addition to these Links, we can introduce some mechanisms to attract customers. A well known mechanism frequently used by the mobile telecom operators is to make the establishment cost as little as possible by subsidizing parts of the initial customer costs. If we reduce the initial cost, customers get attracted and enter a subscription agreement with the company. The normal way for companies to ensure that they get something in return for their subsidies, is to have a lock-in period for a certain time (1-2 years is normal). A similar mechanism can be applied to our business model. Another possible mechanism is to have regular campaigns where our solution is promoted heavily by advertising and offer discounts for a limited campaign period only. But, the most important for us, is to communicate our Value Proposition in a clear way. Customers must understand the difference between our new solution and the existing triple play solutions. We offer the customers much more than only triple play. Customers must be made aware of this added value through advertising in various media, Internet, electronics stores, exhibitions and shows, housing cooperatives as well as contractors. To get customers choose this solution before the competitors' offers, they must be convinced that this solution is significantly better and gives them added value.

Retention:
When we have acquired customers, we must ensure that their expectations are fulfilled. The Value Proposition they were offered in the evaluation phase must be delivered in a satisfactory way. We can introduce some mechanisms to ensure that customers are satisfied and will stick to our solution. Maybe the most important mechanism is the home network user interface which is a part of the Value Proposition. The UI must deliver all the desired services to the customers in a stable and clear way. It must be easy to use and good customer support must be emphasized. The seamless integration of services and devices through the user interface is our main selling point toward other existing triple play solutions. Hence, it is essential that our customers feel that this solution works and gives them increased utility. A simple mechanism that can help us improve is to hand out regular questionnaires to both new and established customers. In this way, we will get feedback of what areas we can improve on and what customers are

satisfied with. Another important mechanism is the constant remote management of the home network. By using remote management, we can ensure that services are delivered according to their service class and assist customers when problems occur. This mechanism will help keeping the quality of the system stable and make customers more satisfied.

Add-on selling:
The home network user interface will be a very important link for add-on-selling. Easy to follow procedures for VoD, pay-per-view and order of additional services along with rich information, advertising and regular offerings attract customers to try the service. If we manage to make the customer satisfied, he or she will continue using the service. An additional mechanism which can contribute to both customer retention and add-on selling is to introduce a bonus-point scheme for content bought through the VoD and pay-per-view service. For each time customers buy content through this service, they obtain a certain amount of points. When a particular level of points is reached, the customer obtains certain benefits as for example reduced price or a gift. This mechanism will encourage people to buy more to get the benefits of the next level and at the same time lead to a lock-in effect to the service. In addition to the home network UI, other links as the company homepage, the telephone support, electronics stores and exhibitions can contribute to add-on selling.

5.3 Infrastructure management

The third main group of elements explains how the company creates value. Infrastructure management describes the value system configuration necessary to deliver the Value Proposition and maintain the Customer Interface. It explains which activities that creates and delivers value. Activities can be carried out within the firm or through a partnership with another company. Capability, Value Configuration and Partnership are the three elements in this group. We will now look into each of them in turn.

5.3.1 Capability

The fifth building block in our business model is Capability. It describes the ability to execute a repeatable pattern of actions. To offer a complete Value Proposition, a company needs several capabilities. A Capability is based on a set of resources. A resource can either be internal or come from an actor which has a partnership with the company.

A resource can be seen as an input to the value-creation process. The resources create the basis for the Capabilities which in turn form the Value Proposition of the firm. We distinguish between three types of resources:

- *Tangible*: This group of resources includes physical assets as for example property and equipment.
- *Intangible*: Within this group falls non physical resources as for example copyrights, patents and valuable brands.

- *Human*: Human skills are of crucial value for many companies. All resources that are based on human knowledge fall within this group.

In our case, we utilize a wide range of various resources to form our Value Proposition. We will list the most important ones and mention whether they come from within the company or from a partner and what type of resource it is.

Network Infrastructure and Equipment:
This is the most important resource and is the foundation for our entire business. To create services for our customers we are dependent on a well developed infrastructure and high quality equipment. We include the core network, access networks, routers, servers, head-ends and residential gateways in this group. This is a *tangible* resource and represents enormous values for the company. We assume that the entire network infrastructure is owned by the company itself. But in many cases, network operators utilize Local Loop Un-Bundling (LLUB) and "rent" access networks from other companies.

Software:
Computer software is used for several purposes in the company. Some software is mass produced and bought from actors in the software market, while other is developed especially for the company. Software bought from others represents *intangible* resources because the value itself lies in the right to use the software. Self-developed software on the other hand can be seen on as both *tangible* and *intangible* resources. The physical part of the software (the code) is tangible and can be changed when the company wants, while the copyright to the software is an intangible resource. For this business model, the middleware (among others the home network user interface) is closely connected to the Value Proposition. Hence is this resource very important for how customers experience the entire home network solution.

Multimedia content:
To distribute television and offer a VoD service, we need access to TV-channels and content of many types. This is achieved through cooperation with television programmers as well as various actors in the content industry. Rich and at all times updated content is crucial to be attractive for today's users. The customers must have the possibility to choose within a great variety of TV-channels, individual programs, sports events, movies, concerts and so on. Content is an *intangible* resource, because the network operator only conveys a right to use the content to the customers. Customers buy a right to use the content and not the content itself. The content is at all times owned by the content's copyright holder.

Employees:
The employees within the company represent a very important *human* resource. Developers, engineers, managers and support personnel hold important human skills that are crucial for the company. Also employees at the partners' organizations that are involved in the cooperation are important resources for the company.

These groups of resources are combined in different ways to create capabilities which make the Value Proposition. The core capabilities of our company will be the ability to deliver all necessary communication and information services over the same physical

access line and establish a complete home network solution in the customer's residence. The ability to customize services and content delivered to each customer gives added value. By keeping the infrastructure, software solutions and services up to date at all times, we will try to stay a step ahead of competitors in the market. The home network UI, personalization through VoD and pay-per-view services as well as the integration of all in-home devices are central offerings formed from the capabilities in the company.

5.3.2 Value Configuration

The sixth building block is the Value Configuration which describes how a company arranges one or several activities to deliver its Value Proposition. In our case, the Value Configuration is a value network. The company itself is not a network, but it provides a networking service. Rather than focusing on logistics, products, transformations and delivery, the network operator must focus on network promotion, contract management, service provisioning and infrastructure management.

A Value Configuration is made up of a set of activities which are actions a company performs to do business and achieve its goals. Each activity has some attributes which describes it:

Activity Level: An activity can either be a *primary* activity or a *support* activity. A primary activity is involved in the creation of the value proposition and its marketing and delivery, while support activities are other activities that allow the primary activities to take place. Example of support activities can be human resource management and technology development.

Activity Nature: This attribute describes the type of primary activity and depends on the type of Value Configuration we have. In our case, we have a value network and this configuration type distinguishes between three types of primary activities:

- Network promotion and contract management cover all activities that deal with acquiring new customers to join the network as well as initialization, management and termination of contracts.
- Service provisioning covers activities associated with establishing, maintaining and terminating services and billing of received value.
- Network infrastructure operation consists of activities associated with developing, maintaining and operating the physical network infrastructure.

We will not list all possible activities in the company, but rather mention examples of the core activities in our business.

Primary activities:

Network promotion and contract management activities:

- Marketing is a very important activity to acquire new customers. This is often done through various types of advertising.
- Contract entering can be done through the web, the telephone service or through an electronics store.

Service provisioning activities:

- Establishment of services must be performed quick and smoothly on demand.

- Maintenance of services. All services must be monitored and maintained to ensure correct operation. Each service must be delivered according to the service class agreed upon.
- Perform billing based on subscribed services and consumption of additional content (e.g. VoD).
- Customer support must be emphasized to keep customers satisfied.
- A RMS system that ensures end-to-end QoS and controls operation of the residential gateway.

Network infrastructure operation activities:

- Connect a residence to the access network through a residential gateway.
- Lay optical fibre to a single house or a housing cooperative.

Support activities:

- Research on new technical solutions.
- Development of new and improved software.
- Training of employees.

There exist many more activities in a company. Instead of listing lots of activities, we have displayed the various groups of activities that exist in a value network and exemplified by mentioning some activities.

5.3.3 Partnership

The seventh building block is the partnership network. A Partnership is a cooperative agreement between two or more independent companies in order to carry out a project or an activity together. To describe the terms and conditions of a Partnership, we introduce the sub-element agreement. This sub-element contains several attributes that describes the partnership with the other actor. To understand the meaning of each attribute, we will explain them shortly:

Reasoning: The reason for the partnership. The partnership can have three objectives for the main company:

- *Optimization and economies of scale* (i.e. outsourcing)
- *Reduction of risk and uncertainty* (several actors share the risk)
- *Acquisition of resources* (need some resources from the other actor)

Strategic importance indicates how relevant a relationship is to the business of a company. This attribute is measured from {0-5} where 5 means high strategic importance.

Degree of competition indicates whether the partner is a competitor or not. {0-5}

Degree of integration indicates how closely two actors are linked together. {0-5}

Substitutability indicates how easy it would be to find a substitute partner offering the same arrangement. {0-5}, where 5 means very easy.

For our business model, we need some partnerships to be able to deliver all desired services to the customers. We will first look at which services the network operator can handle by itself and which services it should enter a partnership to carry out to the customers. The partnerships are summarized in table 5.3 where a short description and all attribute values are given.

Internet and VoIP are services that mainly rely on a network infrastructure and a middleware that control them. In this model, we represent a network operator which controls the network from end-to-end and these services can be delivered mainly by internal resources. But, some services also rely on resources that the network operator does not control. Television, VoD and pay-per-view demand copyrighted content that they have to acquire from others. To do this, the network operator has to enter several partnerships with broadcasters as well as actors in the content industry. The reason for these partnerships is *acquisition of resources*, where the resource is TV-channels or independent content. The strategic importance of these partnerships is very high since TV, VoD and pay-per-view services are very central in the Value Proposition. The degree of competition can also be present for some of the partnerships. In some cases, television companies hold the rights to distribute several TV-channels and convey these directly to end-users as well as other distributors. Hence, the network operator might face some competition from some of the television companies. The degree of integration is not very high for any of these partnerships. The network operator only has to buy the rights to resell their content and do not integrate the other company directly in the business. The degree of substitutability depends on whether there are several actors with right to resell the same content or not.

To set up and maintain the physical installations in each residence, the network operator needs equipment and expertise. As we see it, at least two partnerships are needed to do this. A partnership with one or several actors that can deliver equipment as residential gateways, set top boxes and other technical equipment used in the home network solution is needed. It is very important to have good agreements with equipment manufacturers to get the establishment costs as low as possible. Each residence needs one residential gateway and one set top box per TV-set. This will be one of the main contributors to the establishment cost. Working hours for installation of the home network are also expensive and contributes to high establishment costs. Even though the home network solution will try to utilize existing infrastructure within each residence and prepare for self-installation by the customers, installers are needed in many cases. Hence, a partnership with an installation company is also necessary. Both of these partnerships' intention is to *acquire resources* (equipment and expertise).

The degree of strategic importance is very high regarding the partnership with the equipment manufacturer. Both high quality technical products and low prices are crucial for the business. The network operator will not face directly competition from the equipment manufacturer. This actor might cooperate with other network operators which in turn are competitors, but direct competition will not be an issue. The network operator should request a partnership where the equipment manufacturer supports some of the initial costs of each establishment in return of gradual repayment during the period the customer is locked in. In this way, the equipment manufacturer gets integrated in the business and shares some of the risk by subsidizing new customers. Finding a new supplier of equipment is of course possible, but not trivial since

requirements and software must be integrated in the specific equipment. Hence, partnerships with equipment manufacturer should preferably be long lasting relationships.

The partnership with the installer company has some strategic importance since they are working directly with the customers and hence are indirect representatives of the network operator. The installers must be well known with the technical solution and the equipment used. They must see to that the entire solution works properly each time they do a new installation. The network operator faces no or little direct competition from the installer company and they are not particularly integrated in the business other than knowing the technical solution and equipment. An installer company is pretty easy to substitute with another actor.

Advertising and shopping

Advertising and shopping through the home network user interface is one way for the future network operator to generate revenues. To secure regular income, the network operator should enter partnerships with actors within the advertisement industry. By providing shopping in connection with advertising, customers can actually buy the products they see advertised directly form their TV-set. This will increase the value of the advertisements and hence the income. Transaction cuts can be obtained when sales are carried out from the network operators system. The strategic importance of these partnerships is high since they lead to direct income, without significant costs attached. The advertisement industry is big and it is easy to substitute the partnerships or have several partnerships in parallel. The advertisers do not need to get particularly integrated in the network operator's business.

We have now mentioned some actual partnerships in the business model. Since this is a general model, it is difficult to present details on each agreement. In a company specific business model, more information of each partnership with quantified expenditures and costs should be present. In table 5.3, the various partnerships are displayed along with the belonging attribute values.

	Television	**VoD and pay-per-view**	**Equipment manufacturer**	**Installer company**	**Advertising and shopping**
Reasoning	Acquisition of resources	Acquisition of resources	Acquisition of resources	Acquisition of resources	Acquisition of resources
Strategic importance	5	5	5	3	4
Degree of Competition	3	1	0	0	0
Degree of Integration	1	1	3	2	2
Substitutability	3	3	2	4	5

Table 5.3: Overview of partnerships needed to set up a home network solution and deliver the most common services.

5.4 Financial Aspects

The fourth and last group of elements treats the financial aspects in this business model. The elements Revenue Model and Cost Structure are the outcome of the rest of the model's configuration. Together, the elements determine the firm's profit- or loss-making logic and therefore its ability to survive in competition.

5.4.1 Revenue Model

The Revenue Model describes how the company makes money. More specific, it measures the company's ability to transform their Value Proposition into money. The Revenue Model is composed of several revenue streams and pricing elements. These sub-elements describe an incoming money stream and define the mechanisms used to determine the price of the services offered to the customer. For each stream, we will describe what kind of stream it is (where the money comes from) and the method used for determining the customer price.

We distinguish between these six types of streams:

- *Selling*: giving away certain aspects of ownership of a good or services in exchange of money.
- *Lending*: giving something away for a period of time. (e.g. bank loan)
- *Licensing*: giving someone the right to do or have something in exchange for a licensing fee.
- *Transaction cut*: commission paid to an actor which closes a deal between two other actors.
- *Advertising*: informing or praising something publicly through a media in order to influence the recipients. The publishers get paid for the message.

We differentiate between three pricing methods:

- *Fixed pricing* do not differentiate in function of customer characteristics, volume or real time market conditions. (e.g. pay-per-use and subscriptions)
- *Differential pricing* is either based on customer or product characteristics, volume or linked to customer preferences, but not based on real time market conditions. (e.g. telephone or power usage)
- *Market pricing* is based on real time market conditions. (e.g. auctions)

We will now go through the main revenue streams to provide an overview of how a network operator shall generate revenues. Detailed information and numerical estimates are not provided since this model is too general to give any valid measurements.

The main share of the income will come from the customers. Customers are charged monthly for the services they subscribe to. This gives a monthly revenue stream based on each customer's usage and subscriptions. In addition to the monthly fee, all customers must pay an establishment fee which covers parts of the home network establishment. We will first look into the monthly revenue stream that is calculated with the subscribed services as a basis. We treat each service in turn and look at its pricing mechanisms.

Internet
Broadband subscriptions today are mainly based on *fixed prices* and the customer cost is independent of usage (connection time and amount of data transferred). In our business model, we will suggest a similar scheme for all best-effort Internet traffic. Customers can choose between different connection speeds and pay accordingly. Hence, a share of the monthly fee will be the fixed price for having the broadband connection which gives access to all best effort web services. If customers want a higher level of QoS, this will be charged additionally. For example enthusiastic on-line gamers might want to pay an additional fee each month to get a higher level of QoS when they are playing. A broadband connection can be identified as *licensing*, because the network operator gives the customer access to the network in exchange for a fee.

Television
The television service will be invoiced according to each customer's composition of TV-channels. Some customers want a basic television offer with a few channels, while others want specific sports and movie channels. The prices for the various packages of channels are *fixed* (typical "menu pricing"). Hence, customers pay the same price each month for their television package, independent of whether they watch these TV-channels or not. Television can also be identified as *licensing*. The prices for television depend on our agreements with partners in the television business. One share of the income goes to our partners which are the rights holders to the TV-channels. The other share shall cover the network operator's distribution costs.

Telephony
The VoIP service will be based on two pricing methods. One part of the fee is a *fixed* monthly cost for subscribing to the service. This subscription includes free calls to other fixed telephones within the same country or region. Phone calls to mobile phones as well as international calls will be priced using *differential* pricing. The duration of the call and the country of termination decide the cost. This is how traditional telephony has been priced. Because VoIP uses the same IP network as Internet and television, costs are reduced compared to traditional telephony. This makes it possible to price VoIP lower than POTS. VoIP is also based on *licensing* since the customers buy access to the VoIP service.

VoD
VoD is a quite new service and is currently only on the starting line. We think that this is an up and coming service that will attract many users over time. When the technology makes it possible to watch "what you want – when you want," people will choose VoD above traditional television over time. To make VoD attractive, good pricing mechanisms are necessary. The price of the content is mainly set by the rights holders. Hence, we have to cooperate closely with the content industry to get good deals and a clear pricing scheme that the customers understand. VoD content should be priced with *fixed pricing*. VoD will typically be "menu-priced" where customers can choose in a great variety of movies, programs, sport events etc. Collections of content should also be sold to a reduced price. A football supporter for instance, should be able to buy access to all matches where his team plays at a price lower than buying all matches individually. In this way, it will be advantageous to buy the entire "package." VoD is identified as *licensing* because the customers buy access to some content for a specific amount of time. As we mentioned in section 5.2.3, a bonus scheme can be introduced for VoD

customers. For each piece of content the customer buys, a certain amount of bonus points are obtained. When the customer reaches a determined level of points, he or she will gain advantages as for instance reduced prices. In this way, frequent users get rewarded through certain benefits.

nPVR
A networked PVR service will also be a typical *licensing* service where the customers pay a *fixed price* to be able to utilize the PVR functionality in the network. Differential pricing would also have been possible. Then customers had to pay each time they used the service. We have selected a fixed pricing method because we find it easier to understand and deal with for the customers.

Other services as networked storage and backup, alarm and surveillance systems as well as heating and ventilation control can be implemented for existing subscribers. All of these services are also typical *licensing* services where the customers get access to the service in exchange of a monthly fee.

Establishment cost
For new customers, we charge an establishment cost that covers parts of the installation. Despite high costs for equipment and in-home installation, we must try to minimize this establishment cost to not frighten away customers. A high installation cost might prevent many from installing the home network solution. Since customers' need for installation assistance and equipment vary much, we think the total price each customer pays for installation must be differentiated. One share of the establishment cost should be a *fixed price* that covers some of the equipment and administration costs. This fixed part is common for all customers. The other part is based on *differential pricing* and is adapted to each customers need for new equipment and man hours for installation. In this way, customers that have little need for in-home wiring and can handle the installation themselves get a lower establishment costs than more demanding customers. The physical installation as cabling in customers' residences is a service that is sold through the partnership with an installer company and should be covered fully by the differentiated part of the establishment costs. Equipment as residential gateways and set top boxes are not sold to the customers, but rather licensed. All customers need one RG and one STB and the cost for this equipment should be included in the fixed establishment cost. Are customers demanding additional STBs, a fixed price per STB is added to the monthly invoice.

We have now mentioned several revenue streams which all come directly from customers. Another important source to revenues is advertising. By selling advertising space, the network operator can get additional income. The home network user interface will be frequently used to change TV-channels, check the TV-program, order VoD content and to control other services. This, together with the possibility to personalize advertisements makes the home network UI a valuable place for advertising. Advertising in connection with VoD content can also be very important to increase income and attract more users to the VoD service. We introduced VoD as a fixed price service where customers can buy access to certain content. By offering the same content with some sort of advertising connected to it, the content can be sold at a cheaper price or maybe offered freely. Hence, advertising will "subsidize" parts of the customer cost for the VoD content. A football match can for example be offered at a certain price

without any commercials in addition to be offered at a reduced price with advertising. Customers that value this football match highly will probably pay the highest price to avoid commercials, while customers with a lower willingness to pay will maybe choose the sponsored version. In this way, the network operator intercepts a larger segment of customers than just offering one version. No matter what version customers select, the network operator will earn money either from the advertising industry or directly from the customers.

The advertising industry can be a very important contributor to the total income in the business model. Monthly income from customers is of course vital for the business, but is not significantly different form how existing actors price their services. The costs of developing IPTV and additional services will surely be high and income from the advertising industry can be vital for success.

Advertisers want to reach as many people as possible in their target customer segment. In public television and newspapers, it is impossible to differentiate the advertisements spread to various customer segments. Hence, these advertisements reach a much wider group of people than desired. But, through VoD and the home network UI, advertisements and the advertisers target customers can be linked. Hence, only the target customers see the advertisement. This increases the value of the commercials considerably. In addition to deliver personalized advertising, interactivity obtained with IPTV can be utilized to offer shopping from the TV-set. By letting customers interact with a commercial, they can get more information on the specific product and fulfil a purchase directly from the TV-set. This way of combining advertisements and shopping is also increasing the value of the advertisements. It is possible for the network operator to get *transaction cuts* when sales are performed from the home network UI.

Advertises are mainly priced after how much temporal or spatial space they occupy and how many people they reach. This is a *differential pricing* method and each advertisement will be priced individually dependent on these characteristics. For clickable advertisements, it is possible to obtain a higher price when the customer actually clicks on the ad. Hence, combinations of *fixed* and *differential pricing* can be used for the various advertisements.

To summarize the revenue streams we have treated in this section, we provide an overview in table 5.4.

	REVENUE STREAMS							
	FROM SUBSCRIBERS						**FROM PARTNERS**	
Name:	**Internet**	**Television**	**Telephony**	**VoD**	**nPVR**	**Establishment**	**Advertising**	**T-shopping**
Description:	Broadband connection that provides access to all best-effort web services. Available at different connection speeds. Charged monthly.	A wide selection of packages and individual TV-channels. Possibility for customers to customize their assortments. Charged monthly.	VoIP service with guaranteed QoS. Charged monthly. Split pricing scheme.	A wide assortment of content for "rent." Pay-per-view. Menu pricing. Usage charged on the monthly invoice.	Networked personal video recorder. Controlled from the TV-set. Charged monthly.	Parts of the installation costs are paid by the customers at establishment Split pricing scheme. One share for the equipment manufacturer and one for the network operator.	Provide for advertising in home network UI and in connection with VoD. "Subsidize" customers' VoD costs.	Interactive advertisements make it possible to sell partners' products via the TV. A settled commission can be obtained for each sale.
Stream type:	{licensing}	{licensing}	{licensing}	{licensing}	{licensing}	{licensing, selling}	{advertising}	{transaction cut}
Pricing method:	{fixed}	{fixed}	{fixed, differential}	{fixed}	{fixed}	{fixed, differential}	{fixed, differential}	{fixed, market conditions}

Table 5.4: Overview of a network operator's revenue streams. The attribute values are given for each revenue stream.

5.4.2 Cost Structure

The Cost Structure element measures all costs for the company. It consists of a set of accounts which is a registry of expenditures of a certain category. We will mainly focus on costs connected with the development of the home network, but introductorily we will give an overview of costs associated with the entire development of triple play services.

As discussed in (McCartney, 2006), actors in the market indicate that the costs for developing triple play services will be enormous. The entire network infrastructure needs upgrades and new equipment as video head ends and servers are necessary to deliver services as IPTV and VoD. A client / server architecture for all services must be developed and operating as well as marketing expenditures are also a part of the entire picture. We will start by identifying various categories of expenditures and explain them briefly.

Network infrastructure:
The most costly part is the development of an end-end network infrastructure capable of delivering demanding services as IPTV. Both upgrades in existing infrastructure and investments in new equipment as video head ends and various servers are necessary. This development cost is of course dependent on the network operator's existing infrastructure. The condition and size of the existing network infrastructure will be vital for how significant these development costs will be. Investments in connection with IPTV are huge and cost-effective solutions must be emphasized. One important aspect is to maximize the number of users per investment. (hp, intel, kasenna, 2007)
Core networks and often especially access networks need significant upgrades to handle the high demands to bandwidth and QoS. At the customer end of the network infrastructure we face development costs associated with every home network. This part of the development has so far been neglected by network operators and the customers have been left with the entire work and costs of connecting their home. We will go into further details of the costs associated with home network development in the next section.

Middleware:
The network operator needs a middleware client / server architecture that controls the various services delivered to the customers. The middleware describes different software packages that are used for services like IPTV, VoD, nPVR and VoIP. The customers will interact with the middleware through the home network user interface. We have throughout this thesis emphasized the importance of a well functioning and clear home network UI. The UI is dependent on well developed software for all services to fulfil this demand. Hence, the middleware plays a very important role in the development of a well functioning home network solution. It is no doubt that the costs of developing your own middleware are high. As for all software, the number of users of the middleware has no or little influence on the development costs. Hence, development of a middleware for a limited number of users only, is very costly. For small network operators, it might therefore be profitable to enter a development alliance with other operators or buy a finished product. Without regard to whether the middleware is developed by the network operator or bought from others, it is a significant cost. Upgrades and maintenance is necessary at all times and leads to a running cost.

Access to TV-channels and content:
The network operator has to pay the content's rights holders for reselling their content to customers. The network operator buys access to the content and charges its customers for the right to use it in addition to a distribution costs. In this way, the network operator functions as an intermediary distributor between the content industry and the customers. As we pointed out in section 5.3.3, good partnerships with actors in the content industry are important to get access to a wide spectrum of high quality content at reasonable prices.

Operation:
Expenditures related to the operation of the company as salaries, customer support, management and premises represent an important share of the total costs. Effective operation is essential to keep these costs down and to be competitive in the market.

Marketing:
To get customers' awareness and acquire new customers, marketing is necessary. Marketing can be done in many ways and through several channels (section 5.2.2). Independent of what channels the network operator chooses, marketing represents a significant cost. Customers' attention is not achieved for free. Marketing is not only important in the initial phase, but all the time. Hence, marketing represent a constant cost that is very important to allow for.

We have now mentioned several categories of costs which will apply for network operators launching a triple play service. Since we create a general business model, it is difficult to specify the costs in further detail. The various expenditures will vary greatly between the different network operators. In this thesis, our focus is on the home network, and hence we will now focus on the costs associated with the home network development.

Home Network:
To connect customers to the access network and provide them with services as IPTV, one residential gateway and one set top box are needed per residence. In addition to this, it must be arranged for network coverage in the entire home. This can be done through existing wires, by using wireless technologies or by laying new cables (Ethernet) in the residences. Together with labour costs for installing the network, the total costs for enabling "the connected home" might get pretty high. We will now look at the various expenditures separately and discuss ways of reducing the total cost.

In section 5.3.3, we discussed partnerships and among others the partnership with an equipment manufacturer. Every residence needs one RG and at least one STB. The cost for these components is mutual for all customers and represents a great share of the total cost for the home network establishment. By using one or a few manufacturers for deliverance of the equipment, good prices can be obtained because of high volumes. Instead of selling the equipment to the customers, they "lease" it and they are obligated to deliver it back if they quit their subscription with the network operator. The payment for the RG and one STB is included in the monthly subscription fee. If customers need additional STBs, they have to pay an additional monthly fee for this. In section 5.3.3, we mentioned, that the partnership with an equipment manufacturer should be arranged

such that the equipment can be paid gradually. This will help minimize the initial cost and spread the equipment costs over a longer time interval.

The second large cost in the establishment of a home network is the physical interconnection of all customer devices. Regardless of which technology the network operator uses, networking equipment costs money. Because of varying size, age and building material in people's homes, the needs for in-home infrastructure vary a lot. Some residences will be very easy to cover, while others can be both costly and labour-intensive to cover with network access. Hence, installation has to be customized for each residence. This leads to varying costs for the establishment. We think that a basic home networking solution should be included in the standard "package" and all installation costs beyond this must be covered by the respective customer.

5.4.3 Summary

We have now briefly discussed the financial aspects in this business model. Since our model is general, it is hard to go into details on revenue streams and costs for the network operator. Estimations would have been too insecure to actually give any information of value. But it is still important to see how a network operator can generate revenues and what costs it will face. In addition to generate revenues from customer subscription fees and usage of services as VoD, we think advertising can be a very important source to income for the future network operator. The costs of developing a triple play home networking solution will for sure be enormous and new ways of communicating commercials to customers can be important to ensure return on investment.

1.5 Summary

Throughout this chapter, we have built a general business model, step by step. We have discussed how network operators can offer their customers increased value by focusing on home network development and personalization (VoD). By actuating the offerings in the value proposition, a network operator can differentiate itself from its competitor and offer their customers "something more." We have identified some criterions by the target customer and discussed what links the network operator could use to create a channel toward its customers. Relationship mechanisms have been briefly discussed to see how the network operator can care the relationship toward its customer. Resources needed to form a network operator's capabilities have been mentioned. These capabilities are the basis for the network operator's value proposition. A network operator operates in a value network and needs agreements with partners to deliver all its offerings to the customers. Actors in the equipment, content and advertising industry are examples of important partners for the network operator. In the last section, we looked at the financial aspects in the business model. Ways for the network operator to ensure revenues from customers and from advertising have been mentioned. In Figure 5.2, we provide an overview of all elements and sub-elements we have presented in the business model.

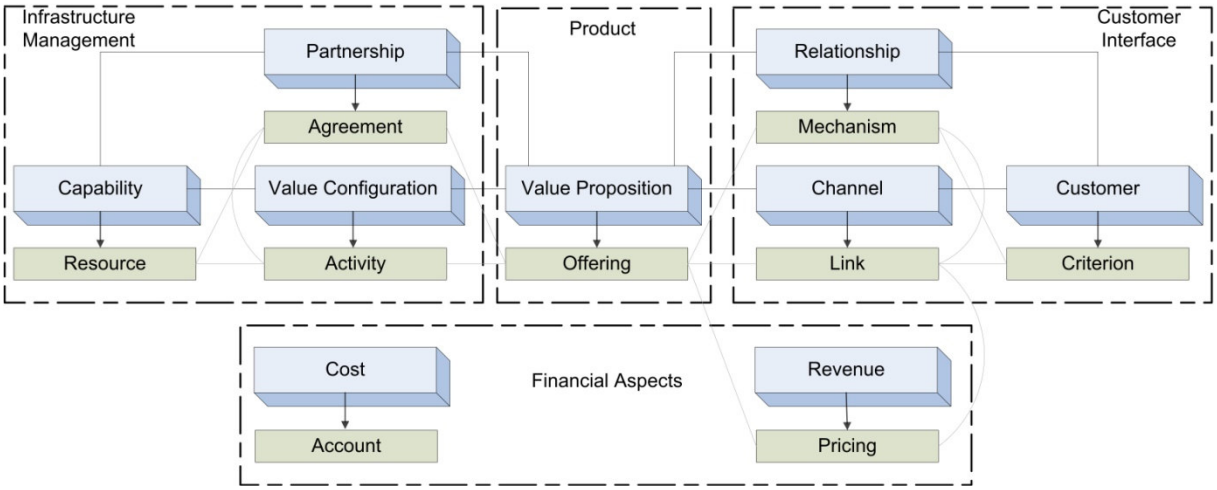

Figure 5.2: Overview of the nine building blocks in the business model. Corresponding sub-elements are connected to each main element. The links between the various elements illustrate how they are related to each other.

Chapter 6
Discussion & Conclusion

6.1 Discussion

The development of triple play services including IPTV implies enormous costs in new network infrastructure and equipment. Telecom operators for instance have to upgrade most of their access network to be able to deliver the necessary bandwidth required by services like IPTV. Many operators hesitate to start developing such services because the costs are so huge and the uncertainty so high. A return on investment must be ensured to get the stakeholders interested. Hence, finding ways of generating profits in the new converged TV/Internet market is essential to speed up the development. (McCartney, 2006)

Converged services have also led to great challenges within the homes. The demand for high quality services like HDTV has increased as people have bought expensive HD-ready LCD and Plasma screens. To transmit HDTV signals, high bandwidth and QoS must be provided all the way to the TV's Set Top Box (STB). Hence, new ways of transporting data within homes must be established, preferably without too high costs. People must be able to connect their devices in a satisfying way. This has been our main focus throughout this thesis. Network operators have discovered the importance of delivering a complete home network solution all the way to the end device. High bandwidth provided by a FTTH connection for example is not very useful without a good way of connecting various devices to the access network. We will now discuss the various solutions we have mentioned in the previous chapters. We will start looking into technical challenges for how to establish the connected home.

6.1.1 Technical Aspects

In chapter 3, we presented a number of requirements for a home network solution. We separated the solution into two main parts; the residential gateway and the physical infrastructure connecting all in-home devices. We will now discuss the various technical solutions and recommend the technologies we find most appropriate to use in the home network.

The RG is the "brain" in the home network and must manage several interfaces and handle many different services simultaneously. It can be seen as the home network's connection point to the network operator's access network. The RG must handle traffic between the home network and the access network as well as all intra-home traffic. We discussed these issues in section 3.3 and mentioned some of the general requirements identified by the Home Gateway Initiative. (HGI, 2006) The residential gateway must differentiate between various services such that QoS parameters can be adjusted to the

specific service. In-home devices must be able to connect directly to each other and other access technologies must be able to connect to the end-devices (e.g. a STB connected to a terrestrial television network). The RG must provide a firewall and manage issues related to security as well as authentication. The home network solution must provide for both wired and wireless connections such that high bandwidth and QoS as well as mobility are available. Ideally, all devices and services would work perfectly on one wireless network making wires and expensive installation redundant. The wireless 802.11n standard is announced to be finally standardized in the middle of 2008 (section 3.5.6) and the market has great expectations to its performance. But, for the time being, we mean that some kind of wired technology is needed to support the most demanding services as for instance HDTV. To satisfy the demand to both mobility and high bandwidth and QoS, the home network must support both wired and wireless connection of in-home devices.

Let us look at the wireless technologies first. Pre-standard equipment based on drafts of the new 802.11n standard is already available at consumer prices in almost every electronics store. This indicates a huge demand which will lead to high competition and low prices for access points and network adapters. We mean that the 802.11n standard (section 3.5.6) seems so promising that it is worth waiting for. The wireless access-point could be delivered independent of the RG, but we think that the best solution is to include the wireless access-point in the RG. This makes installation easier and reduces the number of components present in people's homes. The wireless access point must of course support older 802.11 standards (b and g) in addition to 802.11n. Hence, existing consumer devices with WLAN adapters can be utilized.

The choice of wired technology to use is not as trivial as the choice of WLAN standard. Several factors influence the choice of wired technology. Building construction and existing in-house cabling is decisive for what technology to pursue. The best technology is without doubt the widespread Ethernet standard. (section 3.5.1) It is well proven, delivers high bandwidth as well as QoS and is supported by almost all existing networking equipment. But, few residences have Ethernet coverage today. Hence, existing houses must be covered with new cables. This demands great expenditures in work and wires, especially for older and large buildings. Few people are understandably willing to put too much money in the establishment of a home network. This forces us to find an alternative to Ethernet. In section 3.5, we presented some networking technologies that utilize existing wiring in residences to establish a data network. Power Line Technology (PLT) (section 3.5.2) utilizes the existing power lines, Home Phone Networking Alliance (HomePNA) (section 3.5.3) utilizes both copper telephone as well as coaxial cables and Multimedia Over Coax Alliance (MOCA) (section 3.5.4) utilizes existing coaxial cables within homes. Coax is the medium able of carrying the highest bandwidth, but is also the medium with least in-home coverage in most countries. Power lines are without doubt the medium with the largest coverage in residences, but PLT provides the lowest efficient throughput due to impedance, interference and noise in the medium. Copper telephone lines have a varying coverage in people's homes and HomePNA delivers an acceptable bandwidth through this medium. Hence, several considerations must be taken into account when we evaluate the various technologies. The choice between the various solutions relies on the following factors:

- Coverage of in-home coaxial cabling
- Coverage of in-home copper telephone lines

- Age and condition of existing power lines
- Demand for bandwidth
- Demand for coverage

HomePlugAV which is the prevailing standard based on PLT claims to deliver around 50 Mbps effective throughput and be able to stream 2 HD streams simultaneously. (Intellon, 2007) HomePNA gives a physical throughput of maximum 320 Mbps through coax, but they do not state the effective throughput. (HomePNA1, 2006) MOCA claims that max throughputs can be 270 Mbps and have measured a net throughput over 110 Mbps. (MoCA, 2007) Hence, HomePNA and MOCA are clearly preferable to HomePlug when it comes to bandwidth. When considering MOCA and HomePNA towards each other, we think HomePNA has an advantage as it also supports the use of telephone copper lines which can contribute to greater in-home network coverage. If the coverage of coax and/or copper telephone cables is insufficient, HomePlug might be a better alternative though the bandwidth will be considerably lower. We will not point out one of the technologies as the best. The five factors listed above, must be considered when a specific network operator decides a technology to pursue. The network operator must evaluate the coverage and condition of existing in-home cabling in the region or country it operates. Based on these data together with bandwidth and QoS demands for the services it delivers, the network operator must decide which technology to use.

In addition to support a technology that utilizes existing wiring, the RG must support standard Ethernet. (section 3.5.1) Despite the fact that laying new wires is costly, many small and modern residences with cable sock support will be able to establish sufficient connection points without too much effort. New residences can be constructed with Ethernet along with the power wiring. In that case, Ethernet will replace both coax and telephone cables which are used today. This will clearly give the best solution when it comes to throughput and QoS. As we mentioned in section 5.2.2, contractors can be an important channel for promoting the solution. If the contractor arrange for the home network solution by installing Ethernet in the residence and the network operator establishes fibre directly to the building, customer's establishment costs can be decreased significantly. We mean that Gigabit Ethernet should be the standard of choice to give plentiful of bandwidth for both inter- and intra-home traffic.

The RG must also provide for VoIP service for the customers. (Wallingford, 2005) This can be obtained by including an analog telephone adapter in the RG. Then customers can connect their existing telephone equipment directly to the RG. To cover the entire house, they can either use a wireless DECT telephone with several handsets around the residence, or simply connect their existing copper wiring to the RG and use the copper telephone network as before. This is how most VoIP solutions function today. It is simple, functions well and demands no or minor additional expenses for the customers. Customers can also utilize telephone handsets that work directly toward the WLAN access point.

All in all, we have now suggested including these interfaces to support the home network coverage:

- The new 802.11n WiFi standard (planned finished mid 2008)
- Use of existing power lines, coax /and or telephone lines through the standards HomePlugAV or HomePNA.

- Gigabit Ethernet
- Analog telephone adapter to provide for usage of existing equipment for the VoIP service

It might seem superfluous to include as much as three interfaces for in-home network coverage, but customers have very varying needs and often they do not know what they need themselves. Instead of producing several versions of the RG with different interface support, we think it will be easier and less costly to focus on one version. Most people will in any case have both wireless and wired connection. We think that Ethernet will be the preferable wired technology also within the home environment. But, because the establishment of a new Ethernet network is too costly for many residences, we need an alternative. Hence, we have to support usage of existing in-home wiring.

The STB is the other hardware component delivered to customers. Its function is to decode the television signals and to deliver interactive services through the TV-set. Since IPTV is a demanding service with regards to bandwidth and QoS (section 3.3.3), we have suggested using a wired technology for the in-home connection of the STBs. Hence, each STB must support the two selected wired technologies; Ethernet and one of the standards that use existing wires. The STB must have sufficient processing power to run all necessary software for the entire home network UI and all belonging services. It is important that the operation feels smooth for the customers. Lags and delays are annoying and will lead to discontented customers. Channel swapping, Internet and other services available from the UI must respond quick and efficient. Along with each STB, customers must receive a remote control and a wireless keyboard to control the services.

In addition to hardware, a middleware is needed to control the various services. The middleware is very central in the development of a home network solution and could be vital for success in the market. Whether the network operator shall develop these software packages themselves or buy a finished product depends on the number of potential customers. The cost of developing your own middleware is the same whether the operator has five hundred or one million customers. Hence, the cost per customer must be evaluated when deciding to buy or develop the middleware. It is also possible to buy parts of the middleware and combine this with own developed software.

We have now suggested how a home network can be established physically and which interfaces that shall be supported by the RG and the STB. All this equipment, the middleware and the installation represent significant costs. We will now discuss how we can use the business model presented in chapter 5 to generate revenues such that a Return On Investment (ROI) can be ensured.

6.1.2 Business Aspects

Uncertainty of whether ROI can be ensured is one of the main reasons for why network operators and investors hesitate to invest heavily in network infrastructure and equipment for delivering services as IPTV. As Nanjie discusses in (Nanjie1, 2006), network operators can no longer survive solely on selling voice services. The value of voice services have decreased dramatically and new ways of generating revenues must be found. The network operator can no longer survive only by selling access to a

communication network. The key to revenues lies in services. The value of Internet companies like for instance Google is much higher than any telecom company. Despite the fact that network operators have to invest more money than the Internet companies, the Internet companies get significantly higher revenues. (Nanjie1, 2006) Is this fair when Internet companies use the operators' networks to distribute their services without any costs? Shall the Internet companies be charged for the network usage or should network operators put more efforts in developing their own services to take a share of the cake? We believe that network operators have a golden possibility to offer several value generating services.
In our value proposition in section 5.1.1, we identified several offerings that give customers value. Especially the home network user interface which connects devices and services within the home is important in this value proposition. It differentiates the proposed solution from existing triple play offers and gives the customers added value. It is very important that customers understand what this solution really offers and what value it actually gives them. Most customers evaluate price and perceived quality of the services. The focus on home networking has been absent until now and must be communicated to the customers in a clear way. The establishment of a complete home network solution is the core of our value proposition and we are dependent on customers' awareness regarding home networking to sell it.

Quality of service becomes more and more important for the new and demanding services. (section 3.3.3) By selling "quality guarantees" for various services, operators can differentiate themselves from other Internet service providers that simply deliver best-effort services. If third party Internet service providers want to distribute services with guaranteed quality, they will have to pay for this. In this way, network operators can offer their customers as well as other service providers to buy quality guarantees for specific services. We think that people are willing to pay for guaranteed quality. Many people have invested a lot of money in new equipment like for instance HD-ready TV-sets. Without high quality content, they will not benefit from their investment in modern equipment.

In addition to offer quality guarantees for various services, network operators can benefit from offering personalized services. VoD and nPVR give customers freedom to individually choose when they want to watch their favourite programs. We think that VoD will gradually take over for regular broadcasting. Networked PVR will function as a temporary solution until VoD gets entirely established. If these predictions are correct, today's broadcasters will move from being content producers, television programmers and distributors to mainly focus on content production. High quality content will always be desired by the general public, but we think that composition of various contents into TV-channels will gradually decline and content will rather be distributed independently. This will of course be a long process and television as we know it today will probably continue to be available for a long time.

Today, the television programmers collect content from various sources, create a fixed schedule and broadcast it through various distribution channels. Their revenues are ensured through payments from customers, advertising or a combination of these. Through VoD, the network operator can take over this business. Instead of creating a fixed schedule of various contents, all contents can be made available for the customers and they can watch exactly what they want. Content can be sold with or without

commercials connected to it. By making different “versions” with and without advertising, we can reach a wider customer segment. Customers with high willingness to pay will probably choose the version without commercials, while other customers might accept interruptions of commercials in return of a cheaper price. In any case, the network operator will get paid for delivering the content.

Advertising can create revenues in connection with several services, not only VoD. Interactive television and the home network user interface can be used for both advertising and sales. The home network UI will contain various menus and overviews as for instance a TV-program overview. This can be a suitable place for discrete advertising. By making these ads clickable, curious users can find out more on these products and fulfil a purchase. Sales through interactive television can give the network operator trasaction cuts.

Network operators have different information about their customers. They possess information regarding geographical location, age, sex, which services and TV-channels they prefer and so on. All this information is very valuable for advertisers. Every advertiser has a target customer and their objective is to reach this group of people. Network operators can utilize the information they possess to connect advertisers with their desired customers. This is called personalized advertising and increases the value of the ads significantly.

The network operator should use several links to establish a channel toward its customers. The company homepage, telephone support, advertising, electronics stores, exhibitions, the home network UI and contractors are mentioned as possible links in section 5.2.2. These links should be used to attract new customers, care existing customer relationships and to perform after sales. The company homepage and the home network UI are maybe the most important to create a channel towards the customers. Good customer support is crucial to get the customers satisfied and with that keep a lasting relationship. Since customers are the network operator’s primary source to income, attraction of new customers as well as customer retention is very important factors for success.

Good partnerships with equipment manufacturers, broadcasters and actors in the content and the advertisement industry are vital for a network operator’s success. Profitable agreements with partners can be crucial to minimize costs related to equipment and content and to generate revenues from advertising and sales.

All in all, the financial aspects are dependent on all elements in the business model. But, the customers are the most essential in the network operator’s business. Customers are needed to generate income from subscriptions as well as advertising. Hence, the network operator must emphasize the development of valuable services for the customers. By increasing customers’ utility, the network operator will manage to acquire new, and retain existing customers. User friendliness and good customer support must be ensured to keep the customers satisfied.

6.2 Conclusion

In this thesis, we attempt to answer the problem statements identified in section 1.3. We conclude this thesis by answering these statements, repeated here:

1. What are the technical requirements to the future home network?
2. What existing technologies and solutions can be used to satisfy these requirements for the next generation of home networks?
3. How will the convergence of services and the establishment of "the connected home" affect existing business models?
4. How can a network operator increase customers' utility by offering new home network solutions?
5. How shall network operators generate revenues and return on their enormous investments?

1. The future home network solution will consist of a Residential Gateway (RG) and a physical network infrastructure that connects all in-home devices. The home network must provide full in-home coverage and support both wired and wireless connections to satisfy demands to both mobility and Quality of Service (QoS). The RG must ensure end-to-end QoS by managing all inter-, and intra-home traffic. Customer end-devices must be simple to integrate in the home network without making the system vulnerable and insecure. Ease of use is very important and a remote management system should monitor and control the home network.

2. The RG should support various interfaces to satisfy different demands. Gigabit Ethernet will support high bandwidth and QoS, but demands new wiring in residences. Power line technologies (HomePlug) and technologies utilizing copper and coaxial wiring (HomePNA) exploit existing wiring within the homes to create a home network. This simplifies and reduces costs related to the establishment of a home network. Together with wired technologies, the RG should support the new 802.11n wireless LAN standard. This standard will provide users with mobility and high bandwidth for various services.

3. Convergence of services as television, telephony and Internet will affect the business models used in the market today. Telephone and cable companies will be competitors that offer similar product-packages to their customers. Since telephone companies are experiencing an evident decline in revenues from voice traffic (Nanjie1, 2006), they have to stake on new services to get sufficient revenues. Actors in the television business should focus on content production and let network operators take care of signal distribution. TV-channels as we know it today will probably be gradually replaced by personalized television as Video on Demand (VoD) and pay-per-view services develop.

4. Customers will benefit from easier operation of services and devices through the home network user interface. Interactive television will simplify customer operation and offer new opportunities by combining television and Internet. The remote management system will ensure correct operation and increase customer satisfaction. New services as VoD and networked Personal Video Recorder (nPVR) will increase customer value by offering personalized television.

5. Network operators must deliver several services by themselves and not only offer best-effort Internet traffic. IPTV, VoD and nPVR are essential services to ensure a return on the investments. VoIP and best-effort Internet traffic will not generate enough revenues alone. Services like interactive television and VoD will make it possible to generate revenues through advertising and sales in addition to increase the income from the customers. Advertising can be a vital source to revenues for the future network operator. But, the primary goal for a network operator must be to acquire a large and satisfied customer group. Hence, acquiring and retaining customers by delivering highly valued services and good customer support is the key to success.

6.2.1 Future Work

This thesis treats home networks independent of technologies used in access networks and market conditions. Both technical and business related aspects need further investigation in each specific case. Especially the financial aspects need to be studied in further detail. Detailed cost and revenue analyses must be carried out by performing technical and market related research.

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