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Economic Profitability in the Norwegian Fibre-to-the-Home Market

Karin Ileby

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Supervisor: Steinar Andresen, ITEM
Co-supervisor: Harald Øverby, ITEM
Tore Aarønæs, Norsk Telecom AS

Norwegian University of Science and Technology
Department of Telematics

Problem Description

Fibre-to-the-home (FTTH) is one of the most promising network architectures for providing high speed Internet access to home- and business users. Over the last few years, the Norwegian FTTH market has experienced a huge increase regarding the number of customers and actors in the market. Different FTTH technology has also been employed. However, the current installations of FTTH fail to generate profit for its owners. One can then question whether FTTH, with the current deployment model, will become profitable for its owners in the future.

This master thesis should look into the following issues:
- A survey of the technology choices made by a few different FTTH actors in the Norwegian market
- A survey of different business models used by FTTH actors in the Norwegian market
- Does the choice of technology and business model make an impact on the economic profitability?
- Estimates and future prospects of the future FTTH industry, regarding technology and economic issues.

Assignment given: 29. January 2010
Supervisor: Steinar Andresen, ITEM

Abstract

In today's modern information society, the need for FTTH is emerging. Other technologies may still cope with most of the challenges, but only FTTH does it seamlessly. Also, for the current bandwidth needs, FTTH has a lot of capacity to spare compared to alternative technologies. Thus, FTTH is predicted to be the next leading solution for access networks.

However, the deployment of FTTH is very high cost and actors in the industry are struggling to produce profits. The goal of this Thesis has been to shine a light on factors that influence profitability.

The Thesis presents an overview of available access network technology and fibre in the access network in particular. The Thesis continues to review pros and cons of different technologies. A small survey has been performed identifying the choices made by a few Network Operators. The drivers for FTTH is also discussed, followed by a review of two investment analyses.

A generic macro level model for the FTTH industry is proposed, showing how actors interact in the market. The proposed model is adapted to model the most common operation schemes seen in the Norwegian market; Franchise and Open Access. A business model ontology is presented and used to analyse a generic actor, the Network Operator, on a micro level in the Norwegian market.

It is discussed how the findings throughout the Thesis affects profitability. The discussion has two main areas in regards to profitability; influence by choice of technology and influence by business model. The future outlook in terms of technology and profitability in the Norwegian market is discussed.

This thesis concludes that both business model and choice of technology influences the profitability in the Norwegian market. We identify a few factors

that are likely to shift profitability in a more positive direction over the next few years.

Preface

This thesis is the result of my tenth and final semester of my Master studies in Communication Technology at the Norwegian University of Science and Technology. It has been a five month long work in progress that is now completed.

Working with the thesis has been interesting and challenging. I would like to thank my two supervisors Harald Øverby and Tore Arønæs for interesting discussions and helpful input throughout the process. I also wish to thank Professor Steinar Andresen. Finally I would like to thank everyone who has asked me questions about my thesis, challenging me to find the answers.

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Karin Ileby

Contents

List of Figures

List of Tables

Nomenclature

3P	Triple play services
ADSL	Asynchronous Digital Subscriber Line
AON	Active Optical Network
B2C	Business-to-Consumer
BPON	Broadband Passive Optical Network
CATV	Cable TV
DSL	Digital Subscriber Line
EPON	Ethernet Passive Optical Network
FSAN	Full Service Access Network
FTTH	Fibre-to-the-Home
GDP	Gross Domestic Product
GEM	GPON Encapsulation Method
GPON	Gigabit Passive Optical Network
HFC	Hybrid Fibre Coaxial
ISDN	Integrated Service Digital Network
ISP	Internet Service Provider

ITU	International Telecommunication Union
ITU-T	International Telecommunication Union - Telecommunication Sector
OLT	Optical Line Termination
ONT	Optical Network Termination
P2M	Point-to-multipoint
P2P	Point-to-point
PON	Passive Optical Network
QoS	Qality of Service
SNR	Signal-to-Noise Ratio
TDMA	Time Division Multiple Access
VDSL	Very-high-speed Digital Subscriber Line
WDMA	Wavelength Division Multiple Access

Chapter 1

Introduction

1.1 Background

Optical fibre has for many years been used in the large telecom backbones - the transport network. In recent years an increasing amount of money has also been invested in upgrading the access network through the building of Fibre-to-the-Home (FTTH). According to [1, Chp. 1] more than 8 million homes were connected by fibre in 2008. According to the Fibre to the Home Council Europe as many as 204 550 homes in Norway were connected by FTTH in September 2009 [2]. Many drivers lie behind this development. One is the increase of services delivered through the Internet and the bandwidth that these services require. Examples are multimedia services like streaming of television and music. Further, many service providers seek to deliver triple play services (3P). 3P is the delivery of Internet access, IP telephony and IP Television over a single broadband connection. The fibre access thus becomes a replacement of both the land based phone lines and the copper based television cable systems.

In Norway the building of FTTH has been a part of district politics. FTTH technology was seen as part of the solution to an increasing problem in Norway's countryside; it could help lessen the migration of people from the countryside to the Norwegian cities. A report ordered by the Norwegian District Centre (Distriktssenteret) was published in March this year [3]. The report focuses on the benefits gained for small communities in Norway by the deployment of FTTH. The focus of the report is not pure economic gain.

Many local power suppliers have seen FTTH as a golden opportunity and have deployed FTTH to their customers, financed by their own resources. According to Norsk Teleinfo more than 70 actors now operate in the Norwegian FTTH market [4]. However, the building has not been cheap. It has been estimated at an average cost of 30.000NOK [5] per connected household. There have even been reports on local builds with a cost per connected household of up to 70.000NOK [6]. The main cost lies with the installation of the fibre itself. So the question is; is this profitable?

1.2 Problem

The following issues shall be explored by this thesis

- Survey the technology choices made by a few different FTTH actors in The Norwegian market.
- Survey of different business models used by FTTH actors in the Norwegian market.
- Does the choice of technology and business model make an impact on the economic profitability?
- Estimates and prospects of the future FTTH industry, regarding technological and economic issues.

1.3 Limitations

This thesis will firstly be limited to discussing the FTTH market in Norway. Further, the thesis will discuss the different aspects of FTTH mentioned above, but will stay clear of the political aspects of the matter. This report will take its base in technology and build from there. No attempt will be made to make this thesis an exhaustive survey of the Norwegian FTTH market. Rather, a limited number of actors will be chosen and used as case studies.

1.4 Structure

The structure of this thesis is as follows

- Chapter 2 - Technological background. This chapter will review different access network technologies and different types of FTTH.
- Chapter 3 - Market background. This chapter will review some of the market drivers of FTTH. One section of this chapter reviews two investment analyses.
- Chapter 4 - Actors in the market. This chapter aims to make a macro analysis of the FTTH market and formalize it into a generic market model. We will build on the generic model to show the dominating models in the Norwegian market.
- Chapter 5 - Business Model framework. This chapter will present the business model ontology that is to be utilized in Chapter 6.
- Chapter 7 - Discussion. Technology choices and business models will be linked to the question of profitability. We will look at the future prospects of the industry.
- Chapter 8 - Conclusion.

Chapter 2

Access Network Technology

An access network is the last stretch of network that connects each individual user to the larger network. It is often referred to as the last mile, local loop and several other names. Optical fibre has dominated the larger transport networks for many years and FTTH is bringing optical fibre to the access network as well.

2.1 Access Technologies

This section will briefly review some possible access techniques to provide broadband services. FTTH will not be discussed in this section as the rest of the chapter discusses FTTH. There are two possible access mediums that already exist and are deployed in the access network; twisted pair and a solution with Hybrid Fibre Coaxial (HFC). Both these access techniques are based on copper mediums. Copper has a series of characteristics that limit the maximum transmission speed. It is subject to, among others; thermal noise, impedance impairments, cross talk, attenuation and propagation and speed distortion. All the mentioned characteristics contribute to deteriorating the transmitted signal over the copper medium [7].

When using twisted pair to transmit speech a minimum of 4 kHz bandwidth is needed. By using Shannon's Theorem [8] we can calculate the maximum theoretical capacity. For a 4 kHz speech channel this capacity is approximately 40 Kbit/s assuming a Signal-to-Noise Ratio (SNR) of 30dB [7].

ISDN

Integrated Service Digital Network (ISDN) is the basis of the Digital Subscriber Line (DSL) principle. Instead of having a 4 kHz channel as above, it has a channel of 80 kHz. Thus the maximum transmission capacity found from Shannon's Theorem changes, allowing for an access rate of 160 Kbit/s. This rate allows for speech and data to be transmitted over the same link. The subscriber line needs to be digitalized for this scheme to work [7]

ADSL

The Asynchronous Digital Subscriber Line (ADSL) technique is an extension of HDSL[1], which in turn is an extension of ISDN. As suggested by the name ADSL has asynchronous transmission speeds, meaning upstream and downstream bitrate is not the same. The ADSL technique uses the band ranging from 4 to 100 kHz for upstream traffic, allowing for rates up to 640 Kbits/s. Downstream traffic is transmitted in the 100 kHz to 1 MHz band, allowing for rates of up to 6 Mbit/s [7].

VDSL

The Very-high-speed Digital Subscriber Line (VDSL) is a further extension on ADSL [7]. It was accepted by the International Telecommunication Union (ITU) as a standard for broadband access in 2001. The standard allows for both asymmetric and symmetrical service. Where ADSL uses the first 1MHz of the spectrum, VDSL is defined to use the first 1.2MHz of the spectrum [9]. This expansion allows for downstream rates of up to 52 Mbit/s and upstream rates of up to 26 Mbit/s [10].

[1]HDSL will not be discussed further here. We refer the reader to Gagnaire's article [7] for details.

2.2 Fibre to the Home Topology

There are several types of fibre access networks in terms of network topology. A topology can be categorised as Point-to-point (P2P) or Point-to-multipoint (P2M) . In a P2M network the traffic is essentially broadcast and the Optical Network Termination (ONT) needs to sort the traffic at the receiver end. In a P2P network the last leg of fibre is a dedicated link, thus there is no need for sorting the traffic at the receiver.

2.2.1 P2P

In a P2P configuration a dedicated line runs from the Optical Line Termination (OLT) to the ONT. In the term dedicated lies the fact that this link is not shared by any other users. A single fibre is installed from the OLT to the ONT. The single fibre carries upstream and downstream traffic. This can be done by Time Division Multiple Access (TDMA) or Wavelength Division Multiple Access (WDMA) . TDMA will ensure that traffic is not sent simultaneously in both directions, while WDMA will allow simultaneous transmission on separate wavelengths. The P2P layout is very simple, see figure 2.1. However; as many customers are connected, there might be some fibre congestion at the OLT [11]. Also one needs to consider the fact that if N customers are connected and the length of fibre needed for each customer is L meters, this solution requires N*L meters of fibre.

2.2.2 P2M

While the layout of the P2P topology is very straight forward. The use of P2M opens up for several possible layouts. Examples are ring, star and bus architecture. Illustrations are shown in figure 2.1.The P2M topologies are more practical in terms of necessary length of fibre and possible fibre congestion at the OLT. However, special attention needs to be pain on fault and error protection. If a single fibre should break in the P2P layout, this would affect only one user. However, faults occurring in the other layouts

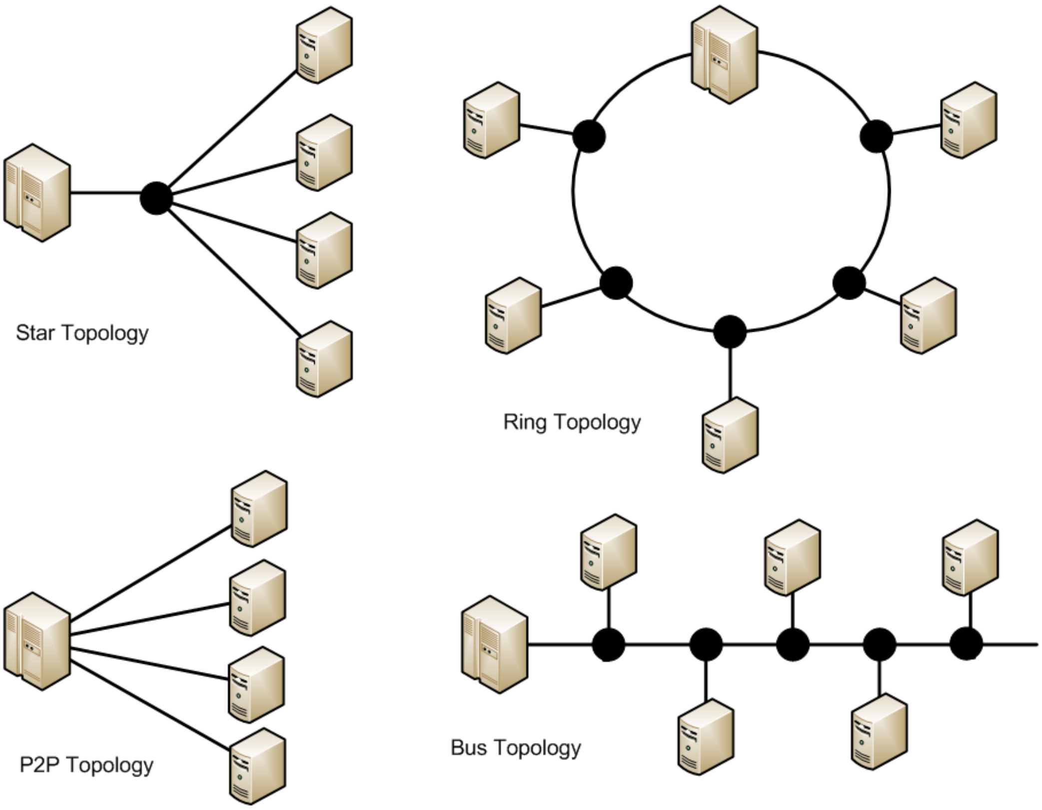

Figure 2.1: The different topology layouts possible for FTTH. Based on figure 2.1.11 and 2.1.12 in [11].

would most likely affect several users simultaneously [11].

2.3 Fibre to the Home Architecture

An optical access network can either be active or passive. An active optical network (AON) will normally have a P2P topology, whereas a passive optical network (PON) will normally have a P2M topology. The main difference between AON and PON lies with the use of electrical components. In a PON a passive splitter will route traffic to the users. The splitter broadcasts the signal onto all outgoing links and the ONT has the job of accepting or discarding the traffic, depending on the receiver address. In an AON an active switch is used instead of a passive splitter. The switch routes the traffic onto the appropriate link based on the receiver address [11] [2].

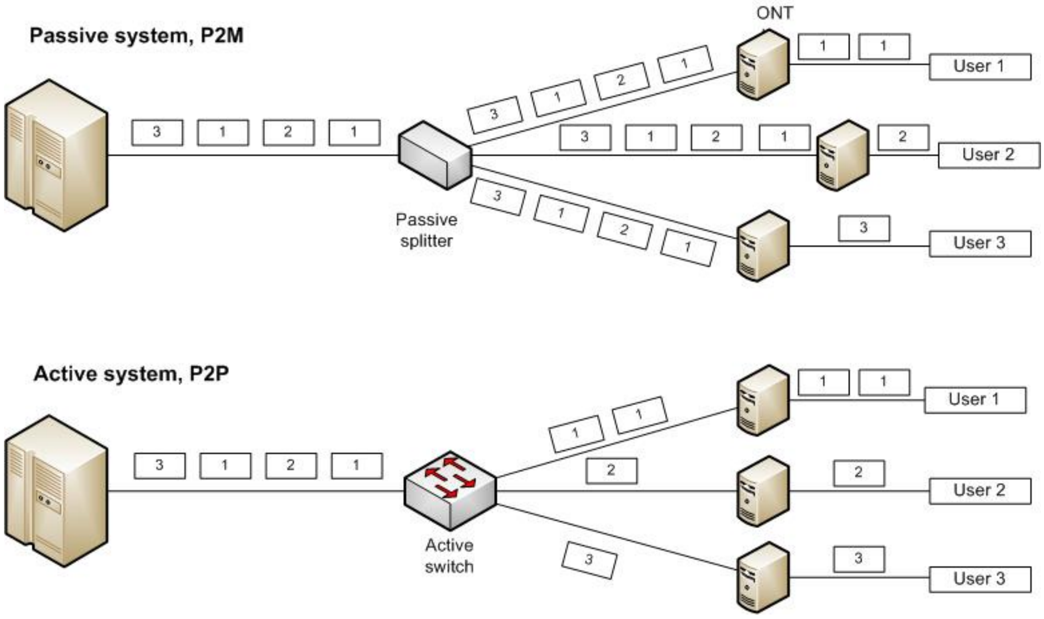

Figure 2.2: Figure depicting the traffic flow in P2M and P2P systems. The fugure is based on Figure 2.2.7 in [11]

2.4 Active Optical Networks

In an AON, as previously stated, a switch is used to route traffic to the users. The switch ensures that traffic is only forwarded on the appropriate link. The switch itself requires electricity and housing. In the case of AONs the MAC protocol is not needed as the last link is dedicated. As each subscriber/user only receives traffic addressed to them the ONT can operate at a lower bandwidth than in a PON. Operation at a lower bandwidth gives a lower unit cost. The dedicated link also gives a higher level of privacy. All subscribers will only see traffic addressed to them and encryption is not as important as in a PON [11].

[2]While doing research for this thesis only sparse literature was found on AONs. Literature on PONs is much more abundant. The sources for the following paragraphs are hence limited. An emphasis has been put on trying to verify the information with at least two sources although only one may be cited.

In terms of delivered bandwidth an AON system can deliver the same bitrate for upstream and downstream traffic. Bandwidth allocation can also be dynamic and adjusted based on demand. The maximum bandwidth per subscriber is determined by the interface type or traffic shaping algorithms [12].

2.5 Passive Optical Networks

In a PON configuration a passive splitter is used to broadcast downstream traffic from the OLT onto all outgoing links. All ONTs receive the exact same information and will need to filter the traffic. Robust encryption is needed in this scheme to prevent eavesdropping. The passive splitter does not need a power supply and the maintenance cost is lower than in an AON configuration [12].

For upstream traffic a scheme is needed to multiplex the information received from the different ONTs. Several schemes exists; TDMA and WDMA are two of the techniques often mentioned. In TDMA each ONT is allocated a time slot in which to transfer upstream traffic and the traffic is thus time-interleaved. The time slots are allocated by means of grants sent from the local exchange. The scheme requires all the ONTs to be highly synchronized. In WDMA no time synchronisation is needed as all the ONTs send upstream traffic using different wavelengths. The same wavelength can be used for both upstream and downstream traffic, a setting which creates a P2P topology [10].

TDMA PONs is the most commonly addressed PON setups. The TDMA access technology is very well suited for high-speed data transmission. In addition the TDMA systems are not to complex and existing electronic integrated circuits can handle the needed signal processing. WDMA, on the other hand, is mentioned as a good candidate for the next-generation access networks. A clear advantage by using WDMA is the fact that the setup creates a P2P topology. A clear drawback is the increased cost caused by the need to sort different wavelengths. The following subsections will briefly review three TDMA PON systems, which have been extensively discussed by standardisation bodies; Broadband PON (BPON), Ethernet PON (EPON) and Gigabit PON (GPON) [10].

2.5.1 BPON

BPON is also known as ATM PON. A BPON delivers downstream bitrates of 155 or 622 Mbit/s and an upstream bitrate of 155 Mbit/s. Each passive splitter can broadcast traffic onto a maximum of 32 outgoing links. The system can cover a maximum distance of 20 km between the OLT and ONTs. Upstream and downstream traffic is separated by using different wavelengths; upstream traffic positioned in the 1,3 μm wavelength band and downstream at 1,5 μm. In BPON all traffic is transferred using cells of 53 bytes each [10].

2.5.2 EPON

EPON is very much like BPON but the fixed length 53 byte cells in BPON are replaced by variable length packets of up to 1518 bytes. This makes EPON better suited for handling IP traffic [10].

2.5.3 GPON

GPON is a further development of the BPON and EPON to provide bandwidths in the Gigabit per second class. The downstream bitrates are 1244,16 Mbit/s or 2488,32 Mbit/s and the upstream link can carry traffic at for different bitrates from 155, 52 Mbit/s to a maximum of 2488,32 Mbit/s. The maximum splitting ratio is increased from 32 in BPON to 128 in GPON. The fibre can, as in BPON, have a maximum fibre length of 20 km. The system is able to carry both ATM cells and Ethernet traffic. This mix makes GPON a highly effective system that can utilize up to 95% of the available bandwidth in the transmission channel [10].

2.5.4 Standardisation Work

The ITU-Telecommunication Sector (ITU-T) has published a series of recommendations for PON, BPON and GPON in particular. The Full Service Access Network (FSAN) group has contributed a great deal to ITU-T's standardisation work. The group consists of representatives from the access network industry; 22 operators and approximately 30 vendors. The representatives comes from all over the world [13].

The Optical Access Network group of FSAN contributed largely to the BPON standardisation series. The series are numbered G983.x and G834.x. The series of recommendations covers aspects ranging from the physical layer to security and management. A second FSAN group, the Operations and Maintenance group helped develop recommendations for GPON, numbered G984.x. The recommendation presents a few enhancements over BPON. Among them is a standard for encapsulation; the GPON Encapsulation Method (GEM). GEM utilizes variable frame sizes to create a system where packets can be transmitted with high efficiency. An enhancement is also added to the security by introducing the use of AES encryption [13].

2.6 Comparison of AON and PON

We have discussed briefly some of the properties of both AON and PON. A comparison of the two will now be presented. The first factor we will look at is bandwidth. When it comes to bandwidth AON seems to be more flexible. It is easier to adjust the bandwidth individually to each customer as there is no passive splitting of signals involved. The current limiting factor of the maximum achievable bandwidth is the ports of the OLT. Thus it is easier to provide each customer with higher bandwidths in an AON as there is a direct link from the limiting port to the customer. In a PON extra configuration is needed to achieve this quality as the output from the OLT port is normally split among several customers. On the subject of bandwidth, AON seems to have the advantage [12].

The next issue we will address is security and Quality of Service (QoS). We have briefly mentioned security in previous sections. In an AON there is virtually no risk of eavesdropping as customers never can reach each other's signals. In a PON setup, the risk of eavesdropping is on the other end of the scale; each subscriber receives all traffic sent to every connected customer on the same splitter. This is handled by introducing encryption. In a PON setup the QoS is also threatened. If an ONT was to malfunction in some way it would only harm a single user in the AON setup. However, in a PON setup the same malfunction might take down its entire tree of as many as 64 customers. Several other issues are also mentioned in [12], however we will not discuss them all here.

We will now look at the difference in cost between AON and PON. Cost is divided into two categories; investment cost and operational cost. We will not discuss much detail here, as we will see more of this discussion later. We will simply point out some key properties. Overall, PON is less expensive than AON both in terms of investment, and operational costs. AON however excels at a few points [12];

- Standard Ethernet equipment can be used as ONT's in AON. The equipment can be purchased inexpensively and off the shelf. In a PON specialized equipment is needed (investment cost).
- Identifying and rectifying malfunctions is easier and more efficient in AON because of the P2P topology (operating cost).
- Upgrades are cheaper in AON because of individual flexibility. In PON you would have to alter all ONT's at once.

2.7 Technology Deployment in Norway

While much focus in the FTTH literature and standardisation work is put on PON[3], it seems that the Norwegian market is going in the other direction. In 2004 Jelle presented in his Master Thesis that the majority of Norwegian

[3]Based on the authors own experience while doing research for this Thesis

actors at that time were in fact deploying active networks [14]. Jelle also makes an example of Lyse, a network operator and local electricity provider in western Norway and the fact that they are deploying AON. We shall see that this has not changed since 2004.

While researching this thesis several actors in the Norwegian market were contacted and questioned on their choice of technical solution. The answers obtained from two actors will be discussed here. One is Eidsiva Bredbånd. They provide an open network to their customers and are connected to Bynett. Bynett will be discussed in chapter 4.2. The other is Signal Bredbånd who provide their customers with the Altibox solution. Altibox is owned by Lyse [15]. The Altibox solution represents a closed network and a local monopoly. This will also be discussed further in chapter 4.2.

Eidsiva Bredbånd state that they primarily deploy an AON solution. They give several reasons for this decision. First of all they base their decision on their own experience; they have always deployed AON and are familiar with it. Further they say that PON is a relatively new solution. As advantages by choosing they highlight that they can utilize standard network equipment which comes in a large assortment and is relatively cheap. They highlight several disadvantages; housing, power supply, climate control, access control and monitoring [16].

Signal Bredbånd also state that they are deploying an AON solution. However, their stated reasons for doing so are slightly different from those of Eidsiva Bredbånd. The primary reason stated for deploying an AON solution is that they are part of the Altibox collaboration and that Altibox is based on AON. They further base their choice on the fact that AON is P2P and each customer has its own fibre. Signal further states that AON is cheaper to plan [17].

Based on the information from Signal Bredbånd we now know that all Altibox partners in all likelihood deploy AON solutions. The Altibox partners make up a substantial segment of the Norwegian market, this will be discussed further in chapter 4.2. Our other example, Eidsiva Bredbånd also deploy AON. It is relatively safe to assume that what Jelle found in 2004 still stands. The vast majority of actors in the Norwegian market deploy AON.

Jelle claims in his thesis that the main reason AON is deployed is a lack of knowledge of PON. This seems to still stand; Eidsiva Bredbånd clearly state that they base their choice on familiarity with the solution.

However, at least one actor in the Norwegian market is deploying PON; Telenor. Telenor is the largest operator within the telecommunications field in Norway, with a history dating back to 1855. Telenor has decided to deploy GPON with a P2M topology. Their decision is based on the cost of the necessary equipment and the expected development of said cost. They also highlight the practical aspects of the passive splitters, such as the power supply and housing [18].

We conclude this discussion for now. Both AON and PON has its advantages and disadvantages, and there are probably different types of solutions where they both excel. However, the lack of knowledge should not be allowed to govern the choice of what technology deployed.

Chapter 3

The FTTH Market

3.1 Technical FTTH Drivers

Though some of the push towards deployment of FTTH stems from ISP competition, much of it also comes from technological advances. A few of the most important technical drivers of FTTH are explained in the following subsections.

3.1.1 Internet Services

Over the last decade the use of the Internet has exploded. Services that were only just emerging in year 2000 are now depended on by thousands of people all over the world. The adoption rate of the new services differs from country to country, but in Norway there is almost not a thing one cannot do online. Instead of going to the bank we manage our accounts and pay our bills online. We return our taxes online, and almost every public service can be managed online, rather than filling out actual papers and going to a public service office to hand them in. Instead of expensive long distance phone calls one can use Skype for free and even add video. The sale of news papers is plummeting as everyone reads news on line. We keep in touch with friends and family through email, Facebook and other online social networks. One can also watch television and movies online, eliminating the need for a

TV, a subscription and having to go to the movies.

Most of these services can be managed by relatively low access speeds around a few hundred kilobits per second. However, the introduction of video demands a lot more in terms of bandwidth if the experience is to be satisfactory [19].

3.1.2 Processing Speed and Consumer Equipment

HDTV has become a frequently used word in television marketing. Film photography has been replaced by digital photography and the price on digital mirror reflex cameras has fallen into the range where it is affordable. Film cameras that record digital High-Definition video are also readily available. As the quality increases, so does the file size. The files from camera devices can easily be transferred to a personal computer by the use of firewire/USB interfaces and a file transfer speed of more than 100 Mbit/s is easily achieved [19].

Simultaneously with the digital recording development, the processing speed of PC processors has continued to follow Moore's Law (meaning a doubling in performance every 18 months [20]). This increase makes it possible to handle the multimegabit files created from our cameras, video cameras and even cell phone cameras. The fact that these files are so readily available on our computers also makes them easier to share, through channels like email and file sharing services. However, this sharing puts demands on the bandwidth. The DSL technology that is dominating the access network cannot handle large file transfers at acceptable speeds. This constitutes a mismatch that will not be abated until optical fibre access networks are brought closer to the home [19].

3.1.3 Triple Play

The convergence of broadcasting and telephony has resulted in 3P, fuelling the need for a higher guaranteed bandwidth. As previously stated, 3P is the delivery of Internet, IP Telephony and IP television as a bundle. The

Table 3.1: Requirements for guaranteed bandwidth for 3P services. Based on Figure 4.18 in [21]

Services	Bandwidth (Mbit/s)
Three HDTV Channels	60
Internet	10
IP Telephone (With Video Conference)	2
Telemetric/Remote Control	1
Total Bandwidth	>75

goal of 3P is for Internet Service Providers (ISP) to compete with cable TV (CATV) operators. As Television over IP opens for new services, like video-on-demand and a higher degree of personal tailoring, ISPs are able to add value to their services compared to the CATV operators. In terms of bandwidth it is estimated that a guaranteed bandwidth of at least 75 Mbit/s is necessary to deliver 3P services. The specifications of this bandwidth estimation is listed in table 3.1 [21].

Table 3.2 shows the bandwidth capabilities of different available access technologies. As shown in the table, only FTTH can provide the bandwidths required for 3P services. Also, with FTTH the signals can travel over longer distances than with any other technology, allowing for fewer active elements in the network [21]. FTTH will also be able to provide for future increases in bandwidth demands.

Table 3.2: Bandwidth and range of differnet technologies over different mediums. Based on Table 1 in [10]

Medium	Technology	Bitrate (down/up)	Reach (km)
Twisted pair	ISDN	144k/144k data incl. 64k/64kbit/s voice or data circuits	< 6
Twisted pair	SDSL	768k/768kbit/s	< 4
Twisted pair	ADSL	1.5M to 6M/64k to 640 kbit/s	< 4 to 6
Twisted pair	VDSL	26M to 52M/13M to 26Mbit/s	< 0.3 to 1
Coaxial cable	CDMA/OFDM +QAM/QPSK	$<$ 14M/14Mbit/s	
Fibre	ATM	150M to 622M/150Mbit/s	< 20
Fibre	Gbit Ethernet	1Gbit/s	< 5

3.2 The Economic Barrier

Technically speaking, nothing is hindering full deployment of FTTH to every home. The undisputable single greatest barrier for full deployment of FTTH is cost. Consumers are indeed willing to pay more for a larger bandwidth. However, consumers are not willing to pay increasingly more in proportion to the increase in bandwidth. In other words, as bandwidth increases in a rapid pace, the amount consumers are willing to pay per unit of bandwidth decreases. To be able to maintain profits in this situation one out of two things need to happen; the unit cost of bandwidth needs to decrease at a higher rate, or the spending will of consumers need to shift to telecom services [22].

The unit cost of bandwidth depends on the electronic components used in the network. The basis for a network is electronic components and the unit cost of bandwidth follows the same decrease as the unit cost of the electronics, known as the learning curve. As the volume produced doubles the unit cost decreases by approximately 80%. Translated to bandwidth this means that the price has decreased by approximately 80% for each doubling of the bandwidth [22].

As previously mentioned, the amount consumers are willing to pay for their broadband is not proportional to the increase in bandwidth. This can be explained by looking at the gross domestic product (GDP) . In most countries the GDP increases by only a few percent each year. In Norway the GDP actually decreased by 1,6% in 2009 [23]. It is unrealistic for a business to expect a much higher growth than the overall GDP of the country it operates in. A higher growth than the GDP will normally only happen if spending habits of consumers shift, in this discussion shift towards telecom. This however means that some other area loses revenue [22].

3.3 The Transition to Fibre

To make the transition from the old access technologies to FTTH the infrastructure of the network needs to be changed. In the past, an upgrade of bandwidth could be made by using the same transmission medium and changing the electronic components in the network. To make an upgrade to FTTH this update scheme is no longer sufficient; the transmission medium also needs to be changed. As mentioned in the previous paragraph the price of the electrical components have an approximated decrease in value by 80% for each doubling of produced volume. Thus, the price of the new network equipment is not what makes FTTH so expensive to install. The immense costs of FTTH stems from the cost of installing the new network infrastructure.

In the introduction of this thesis it was mentioned that the average instalment cost of FTTH in Norway is 30.000 NOK [5]. According to The FTTH Council Europe Norway had 204.550 connected subscribers in June 2009 [2]. We can assume that this number has increased further since that date. These numbers imply an investment of staggering 6,137 billion NOK.

3.4 Investment Analysis

In this thesis we will not do an investment analysis. However we will use the results produced in two other master theses done by Jelle in 2004 [14] and Skavdal in 2009 [24].

3.4.1 Investment cost of AON vs. PON

Jelle presented a cost analysis, showing the difference in investment cost for AON and PON. For the full detailed version of his analysis we refer the reader to the source. We will focus on the results. Jelles analysis includes the cost of equipment needed in the central and at the user, the cost of switches/splitters and cost related to digging, installation and purchase of the fibre cable. The analysis excludes cost related to additional man hours, the laying of fibre inside apartment buildings and cost related to power and housing for active switches [14].

Jelle's analysis concludes that the average cost per user for building a PON is 15686 NOK and 16456 NOK per customer for building an AON. How the investment costs are distributed is shown in figure 3.1. As seen in the figure, the major cost, regardless of the network type, is the deployment itself. The difference in cost per customer is not remarkably large, but we bear in mind that the electricity supply and housing cost are excluded from the AON.

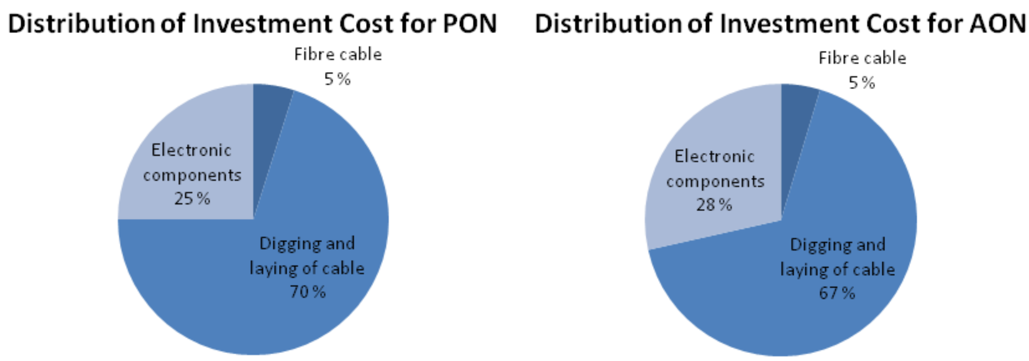

Figure 3.1: Distribution of Investment Cost, based on fure 4.3 and 4.4 in [14]

3.4.2 Investment Cost According to Location

Skavdal took Jelle's concept one step further. In his thesis he performs a full investment analysis in the context of three different locations. The three locations have different properties in terms of building and population mass. The first location (Sjetnemarka) is populated by detached and semi-detached houses. Much of the area consists of greenery. The second location (Kolstad) has a combination of apartment buildings and detached houses. The final location (Nedre Elvehavn) is in densely populated area in a city with a surrounding of high-rise apartment buildings. For the detailed information and cost specifications we refer the reader to the source [24].

Table 3.3: The investment cost per technology per location. Based on table 8 in [24]

Location	**P2P** Investment Cost	**GPON** Investment Cost	Difference
Sjetnemarka	22 574 853	21 607 553	967 300
Kolstad	7 491 005	2 160 755	955 300
Nedre Elvehavn	8 462 964	6 820 193	1 642 771

Table 3.3 shows the investment costs calculated by Skavdal. The most expensive location to build in is the most sparsely populated area, and the most populated area is the least expensive to build in. Skavdal's calculations follow those of Jelle in that digging represents the largest cost and that the deployment of an active network is slightly more expensive than a passive network. In Skavdal's calculations the digging represents between 87 and 62% of the total investment cost [24].

Chapter 4

Actors in the FTTH market

In the first part of this chapter a model for the FTTH market will be proposed. The model will show roles that need to be filled by actors in the market and how these roles interact. The second part of this section will look at the market in Norway and show how businesses fill the roles. We will discuss whether the model fits reality or not.

4.1 Proposed roles in the FTTH market

For a user to be able to buy and use services over FTTH, several roles need to be filled by industry actors. Firstly someone needs to lay down the transmissions medium. Secondly someone needs to provide services over the medium. For the consumer to be willing to buy a product, someone needs to provide the content.

In this chapter the different roles that have to be filled will be discussed. We will look at the market as a whole and discuss which actors are likely to fill each role. A model showing the roles and the interactions between them will be proposed. This model will form the basis for a discussion on how the actors in the Norwegian FTTH market actually interact and fill the different roles in the model. This will provide us an indication of where the money in the industry changes hands.

Some of the roles below will have dependencies, cost and income outside the FTTH market. A very clear example of this is the production costs a Content Maker will have. However, as this is outside the FTTH market we will exclude them from this discussion. We will focus on dependencies and money flows inside the FTTH market itself.

4.1.1 The Builder

The very basis of the FTTH market lies in the fibre medium. Without a stretch of fibre from a local exchange of some sort, and to the user's house, there is no FTTH. Before the use of fibre, copper based mediums were used in the access network. For these reasons, to be able to provide consumers with FTTH someone needs to deploy the fibre to their homes. This role is filled by the builder. The role consists of deploying the fibre, maintaining and managing it. The Builder role is summarized in table 4.1.

Dependencies

The builders of the FTTH in some ways represent the bottom of the food chain. All other roles in the FTTH market depend on the builder in terms of having the actual fibre optic transmission medium. However, this dependency is two sided. Many of the services delivered over FTTH can be delivered by some other means; coaxial cable, the phone network or even wireless networks. The only real use of FTTH, as of right now, lies in 3P and large, symmetric upstream and downstream bandwidth for internet services. If these services are not delivered by ISPs/Content providers, FTTH is abundant. It is also important to keep in mind that the customer must be willing to switch to FTTH, as we can assume that all customers already subscribe to TV, Internet and telephone services elsewhere.

Cost

The largest costs in the entire FTTH scheme are associated with the deployment process, and thus befall the builder. Large investments are needed to deploy fibre. Also, it may take a long time before the investments are profitable. Fortunately, optical fibre is a durable material [kilde] and major maintenance cost is not to be expected. The largest cost of the deployment is the digging, and once a pipe is laid down, the fibre itself can be replaced without digging a new ditch.

Income

There are two possible sources of income; directly from the customer or from the ISP. However, for the income to come directly from the customer is not very likely in a strict FTTH definition. Businesses could lease dark fibre from a builder and take care of the actual transmissions. Strictly speaking, this scenario is not FTTH but FTTB and it is not a likely scenario for consumers to lease dark fibre to their homes and take care of the transmission. The Service Provider and the Builder are in a mutually dependable relationship; neither can do their job on their own. For simplicity we will assume that the Service Provider leases the infrastructure from the Builder, and this becomes the Builders source of income.

Table 4.1: The Builder role

Role	**Builder**
Tasks	Deplyoment of transmission medium Maintenance and management of medium
Dependencies	*To Service Provider* - For setting up transmission capabilities *To Content Provider* - For availability of content that customers will buy *To Customer* - Willingness to switch to fibre
Cost	Initial investment (high) Maintenance cost (low)
Income	From an ISP Directly from customer

4.1.2 Service Provider

The Service Provider is the enabler for the Builder. Together the Service Provider and the Builder is the enabler for the Content provider. The Service Provider is in charge of the actual transmission equipment so that the transmission medium can be put to use. The service Provider needs to install and configure all the network equipment. It also needs to maintain the equipment and monitor it for potential faults. The role of Service Provider is summarized in table 4.2.

Dependencies

The Service Provider obviously depends on the Builder, or there would be no medium to provide services over, at least not FTTH services. The Service provider is also highly dependent on the Content Provider. In all likelihood, no customers would be interested in paying for an "empty" transmission line. The Service Provider needs for the Content Provider to deliver attractive content to the customers. To this end, many Service Providers may choose to cooperate with one Content Provider in a sort of Franchise arrangement. In this setting we will have a closed network, where only one Content Provider may sell its services. Other Service Providers choose to leave its network open for any Content Provider to deliver services and leave the choice up to the customer.

Cost

The Service Provider will, like the Builder, have some initial one-time investments. Here into necessary opto-electrical components, light sources and other necessary equipment. The initial investments of the Service Provider are still far smaller than those of the Builder. After instalment and setup, some operational expenses will continue to run. The setup needs to be monitored for faults. Also faults need to be corrected and malfunctioning components will need to be replaced. Still these costs should be rather minor. In addition, it is likely that the Service Provider has expenses to the Content

Provider for the content available and to the Builder for lease of the fibre.

Income

In our scheme the Service Provider is likely to be the role with the customer contact. The Service Provider mitigates deals with the other roles and present products available for purchase to the customer. To this end the Service Provider is also the most likely to bill the customers and this is the Service Providers most likely form of income.

Table 4.2: The Service Provider role

Role	**Service Provider**
Tasks	Setup and maintenance of transmission equipment Monitoring and repairing system faults
Dependencies	*To Builder* - For deploying the fibre *To Content Provider* - For delivering content to customers
Cost	Initial Investment (mid-range) Monitoring and maintenance (low) Lease of fibre To the Content Provider for services bought by the customers
Income	Directly from the Customer

4.1.3 Content Provider

The Content Provider is in many ways in charge of making FTTH into a product that the Customer is willing to buy. As already mentioned, customers will not be willing to pay for an "empty" transmission line. The general customer, in all likelihood, will not be able to tell the different parts of FTTH from one another. To the customers FTTH *is* the content provided by the Content Provider. The role of the Content Provider is summarized in table 4.3

Dependencies

The Content Provider would not be in business if the customer is not willing to purchase the product delivered. The Content Provider is also highly dependent on the Builder and The Service Provider. The FTTH content, 3P in particular, cannot be delivered over any other medium and thus the Content Provider will not be able to provide this content if there is no FTTH available. In addition to all this, the Content Provider will be dependent on the Content Maker. The Content Makers must be willing to deliver their products over FTTH to the customers.

Cost

The Content Provider will have continual costs to the Content Maker. These costs can be constant (for example per television channel) or variable based on the customers wishes (for example for video-on-demand services). The Content Provider will also have costs connected to monitoring and necessary maintenance and fault correction. Also, the Content Provider will probably have some cost connected to advertising.

Table 4.3: The Content Provider Role

Role	**Content Provider**
Tasks	Providing content that is attractive to customers
Dependencies	*To Builder and Service Provider* - To deploy and operate the fibre access network *To Content Maker* - For wanting to use FTTH as distribution channel
Cost	Monitoring, maintenance and fault correction (low) To the Content Makers (high) Advertising (low)
Income	From the customers

Income

The Content Provider's largest income comes from the customer, probably via the Service Provider as stipulated above. It might also be possible for the Content Provider to earn some money on selling advertising space.

4.1.4 Content Maker

The content maker is more of a peripheral role in this context. We still include it as some of the money will inevitably flow this way. The Content maker can be movie production companies, television channels, music labels etc. The Content Makers already exist and FTTH is just a new distribution channel to them. Thus, we will not define any dependencies for the Content Maker, as they would fall outside the FTTH market. Most likely, the Content Maker will not have any costs associated with delivering content to the Content Provider. They will however have income. The summary of the Content Maker role is defined in table 4.4.

Table 4.4: The Content Maker Role

Role	**Content Maker**
Task	Produce and make content available for Content Providers
Income	From Customer via Content Provider

4.1.5 Customer

The Customer holds the key to the entire FTTH market. If the Customer is not willing to spend money on the products offered, there will be no income for any of the other roles in the market. The Customer will have a loose dependency on all of the other roles. If the other roles do not supply FTTH and its content, the customer cannot buy it either. However, alternatives do exist for the Customers (at least to a certain extent) and thus the dependency is loose. The Customer will not have any direct income from FTTH. The Customer role is summarized in 4.5

Cost

The Customer will have clear costs associated with FTTH. It can be expected that they pay a one-time fee to have the medium installed in the first place.

This money goes to the Builder. A monthly fee for the connection and additional fees for all content delivered is to be expected. The monthly fees are subscription based.

Table 4.5: The Customer role

Role	**Customer**
Dependencies	To the other roles for delivering the FTTH solution (loose)
Cost	Instalment fee (medium/high) Monthly fees based on subscription(low/medium)

4.1.6 Proposed FTTH market Model

Based on the roles defined in the section above the following model of the FTTH market is proposed.

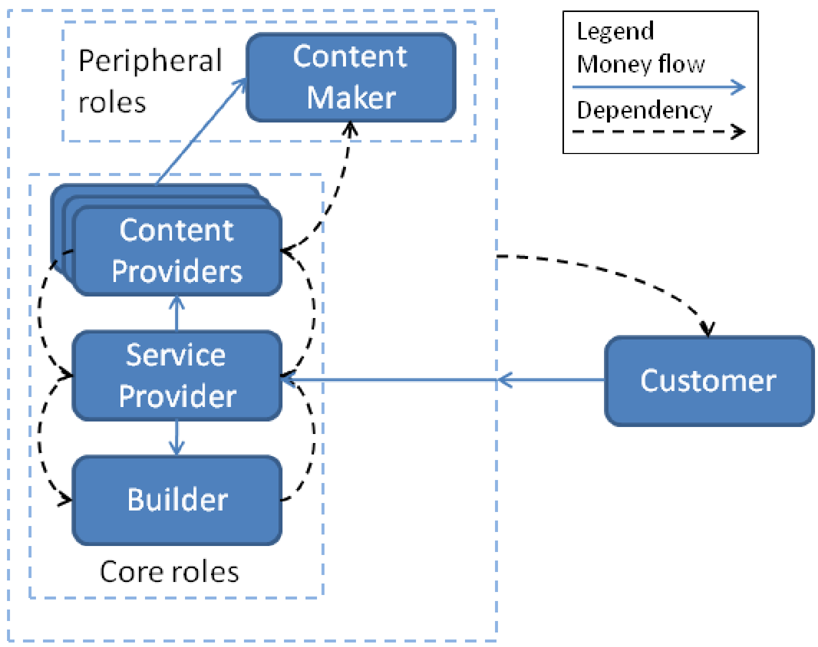

Figure 4.1: Model showing the roles in the FTTH market, their dependenciea and the money flow

As indicated the solid blue lines represent the money flow in the market and the dashed black lines represent dependencies. This model is based on what the author assumes as the most logical behaviour of the actors in the market. In the following section we will look at actors in the Norwegian FTTH market and see if their behaviour matches the proposed model. If necessary the proposed model will be revised.

4.2 The Norwegian FTTH Market

This thesis focuses on the Norwegian FTTH market. Based on the model proposed in the previous section, we will now adapt it into the three main models found in the Norwegian market. We have named them Franchise, Citynet and Free Agents [1].

4.2.1 Franchise

By definition the word franchise means the right to market and sell a company's products in a certain area [25]. In the FTTH context, the word franchise is connected to large Content Providers who licence local operators to sell their services exclusively. The local operators in turn are committed to only selling the franchised services. This gives us a closed network serviced by a single Content Provider. The Builder and Service Provider roles are commonly filled by the same company. We shall dub this double role Network Operator. The Network Operator is often the local electricity provider, wanting to deploy fibre to their customers.

In the Franchise model, no choice is left to the customer it is a "take it or leave it" deal. If they want to have FTTH and its services in their home, they have to buy services from a predetermined Content Provider. Because the cost of building is so high, it is not likely for two Network Operators to be building in the same geographic area. The Franchise model thus represents a local monopoly as no other Content Providers are allowed access.

[1] The three models are based on discussions with Tore Aarønæs and his formulation of the different market models.

Franchise Model

From the generic model of the FTTH market proposed in section 4.1.6, we can now derive the model specific to the Franchise scheme. The model is shown in Figure 4.2.

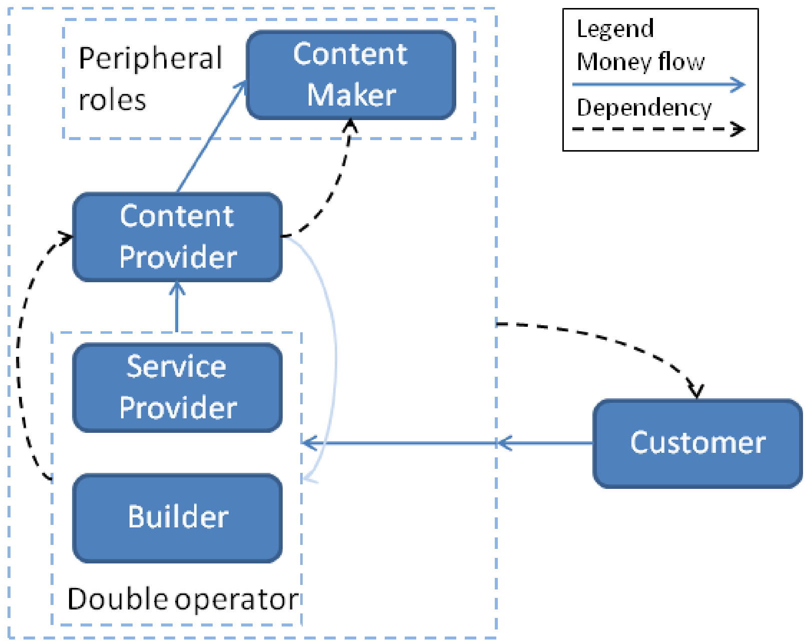

Figure 4.2: Model of the Franchise scheme

The Builder and Service Provider are gathered into one block that interacts directly with the Customer and the Content Provider. The entire scheme is dependent on the Customer. Firstly, the Customer must be willing to invest in installing the fibre. Secondly the Customer must be willing to purchase the content delivered from the Content Provider via the Network Operator. Further, the Network Operator is dependent on the Content Provider as it helps with several aspects, beyond content delivery. This will be further explained in an example below. We also indicated a loose dependency from the Content Provider to the Network Operator. If the Network Operator is not willing to have a closed network, this scheme will not work. In terms of money flow; the Customer deals with the Network Operator and the Network Operator pays the Content Provider for its services. The

Content Provider pays the Content Maker as in the generic model.

Altibox

The largest example of this model in Norway is the Altibox concept. According to Altibox's Internet pages they have 32 cooperating Network Operators in Norway, spread throughout the country [26]. The list of co-operators is dominated by local electricity providers. As we have seen earlier in this thesis, Altibox requires that that the Network Operators must deploy an AON network. We have also seen that this is not always the best solution.

Altibox offers its partners more than just content. According to their web pages [27] they can also help in the start-up phase of Fibre deployment. The majority of their partners not being telecom operators, but electricity providers now point us to a reason why both this thesis and Jelle's thesis from 2004 found a lack of knowledge on PON. They solve their lack of knowledge by finding support and knowledge in the Altibox system. Thus the Network Operators trust in the better judgement of a Content Provider with a brand name.

With the entering of the larger Telecom operators into the FTTH market (e.g. Telenor), we might see that other Network Operators may follow other examples. Telenor is probably an even stronger brand name in the Norwegian market, even though they are relatively new entrants in the FTTH market[2].

4.2.2 Open Access

The Open Access model is in many ways the direct opposite of the Franchise model. Instead of being based on a closed network concept, an effort is made to keep the network as open as possible. Some similarities still exist; it is also common in this model to have the Network Operator solution. The Content Provider role is filled by whoever wishes to fill it. Customers are free to choose from the different Content Providers based on their own preferences.

[2] Altibox have been deploying fibre since 2002 [27], while Telenor are just sarting [28].

Open Access Model

The Open Access Model is shown in Figure 4.3. The Builder and Service Provider are gathered into one block here as well. This block still represents the single point of contact to the Customer. The Network Operator is connected to multiple Service Providers. Between the Service Providers and the Network Operator there exists a strong mutual dependency. Neither have any value to the Customer without the other. Thus they are both also dependent on the Customer. The money flows through the single point of contact from the Customer, to the Network Operator and to the Content Provider that the Customer has opted to buy services from.

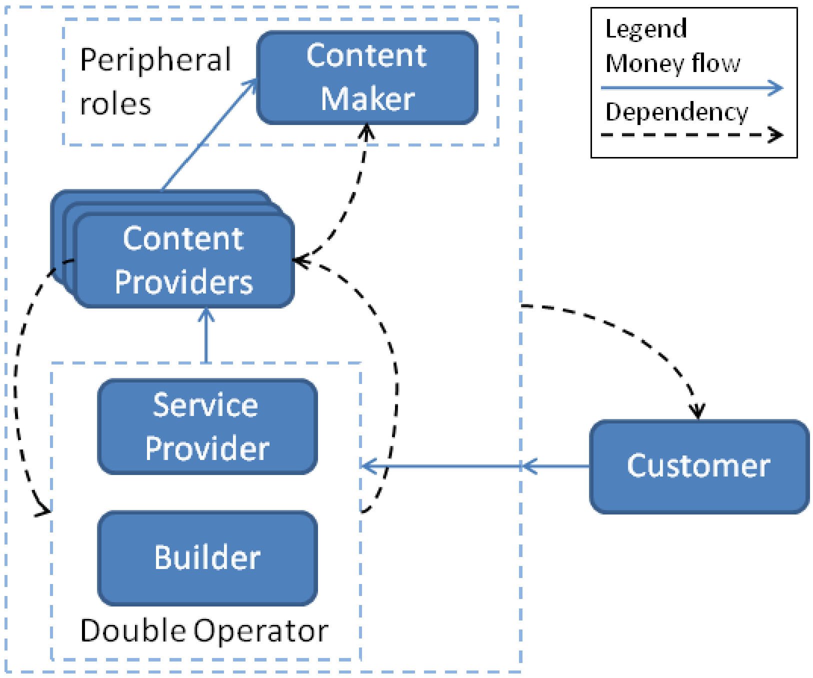

Figure 4.3: Model of the Open Access Scheme

Bynettforeningen

In Norway, several of the market actors operating on the Open Access principles have joined together in a sort of union called Bynett. Directly translated this means Citynet. Bynett has 14 members according to their web site [29]. Bynett is more of a forum for actors in the market believing in the Open Access model. The consortium is meant to give the operators a gathered front outwards [30].

Independent Actors

Under the Open Access model we also find a few independent actors. They are not part of Bynett, but they still provide an open network. One example is Norsk Fibernett AS [31]. The Independent Actors will be modelled in the same way as the actors under Citynet.

As a last mention in this chapter we would like to emphasize that endless variations are still possible within the different proposed models. One variation that should be mentioned in particular is one where the Builder and Service Provider roles are filled by different actors. This can be done within both the Franchise model and the Open Access model. The model of the collaboration will in these cases be very similar to the generic model proposed in section 4.1.6. One example of such a setup is the collaborations formed by NextGenTel in the FTTH market. NextGenTel cooperates with several local electricity providers for deployment of FTTH [32]. In addition NextGenTel is part of the Bynett consortium [29]. NextGenTel, the Service Provider, acts as single point of contact for the Customer. This is as stipulated in the generic model in section 4.1.6.

Chapter 5

Business Model Framework

The first part of this chapter will try to provide a definition of a business model and connect it to other managerial parts of the business. In the second part we will review a framework, developed by Alexander Osterwalder, for classifying business models.

5.1 What is a Business Model?

The term business model is often associated with the Internet boom. So called business models were created that had little root in reality, promising high profits to investors. The whole scheme ended up collapsing in a rather ugly manner. However, many still believe in the business model; given it is used in a proper manner. According to [33] the business model is a story explaining how an enterprise works. It tells you who the customer is and what the customer values.

Magretta states that all business models are in essence a variation of the value chain that all businesses are built upon. In one end you have all activities associated with making a product that can be sold. In the other end you have all activities associated with selling your product. Whether intentional by the business's managers or not; all well running businesses are built on a sensible business model [33]. In the words of Alexander Osterwalder, a business model is described as follows;

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 and delivering this value and relationship capital in order to generate profitable and sustainable revenue streams. [34]

Figure 5.2 illustrates how the business model is connected to other managerial tools in a corporation and the environment that affects them. Outside influence is the reason why business models should not be viewed as static, but rather they are like a hypothesis that should be tested and then revised if necessary [33]. This can be illustrated as in figure 5.1.

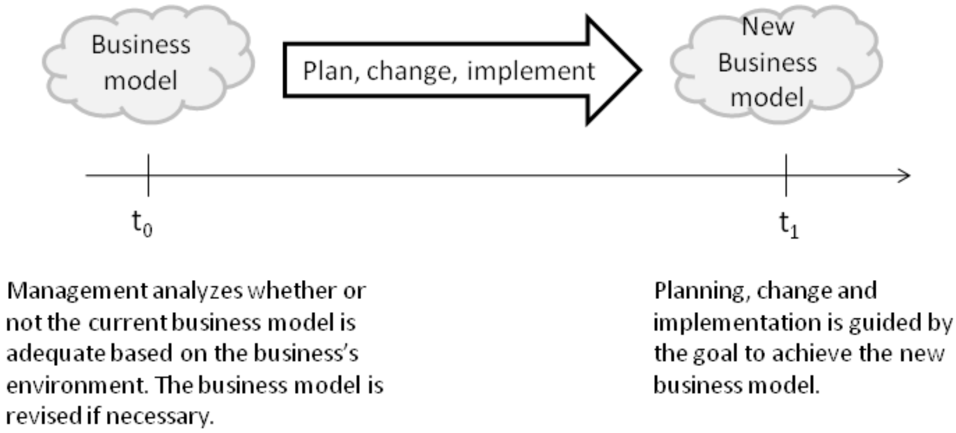

Figure 5.1: Illustration of how a business model should change over time. Based on Figure 12 in [34].

5.1.1 Business model vs. Strategy

Business models are often confused with a business's strategy. However, as the intention of the strategy is to explain how the business will meet its competition, the business model does not factor in competition at all. The business model, on the other hand, explains how every part of the business itself fits together to make a whole [33].

5.1.2 Business Models vs. Business Organization

While Strategy deals with external influences, the business organization is the blueprint of the business's internal, physical structure. The Business model is the conceptual blueprint of the business, while the business organization is the business model's physical implementation. If the business model is altered, the change will normally require a re-evaluation of the business organization [34].

5.1.3 Business Models vs. ICT

According to Osterwalder the link between the business model and ICT is very strong. The reason for the strong link stems from ICT's ability to fuel different types of business models. However, the strong link is not always equally visible. With companies like Amazon.com and eBay, there is no doubt that ICT is a huge part of the core of the business. In companies where the link is not so apparent it is important to consider what impacts ICT can have on the business model and vice versa. Managers need to keep the possible mutual impact in mind [34].

5.2 The Osterwalder Ontology

In Osterwalder's Business Ontology there are four main pillars; Product, Customer Interface, Infrastructure Management and Financial Aspects. The pillars represent the four main areas that need to be addressed by the business model on a coarsely grained level. To have a higher degree of precision, each pillar is subdivided into one or more business model elements. In total, the ontology has nine business model elements. The nine elements and their

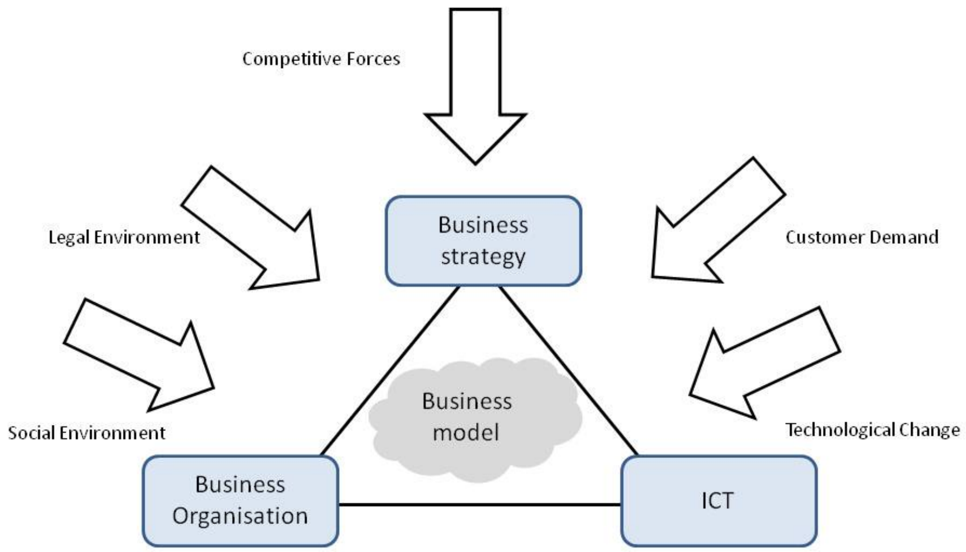

Figure 5.2: The business model's role in a company, connected with the strategy, the business organization and ICT, being influenced by the environment. The figure is based on Figure 8 in [34]

relationships are what make the complete business model [34]. Table 5.1 lists and explain all the elements of the model.

Figure 5.3 shows how the nine business model elements in the osterwalder ontology are related to each other. The goal of mapping the nine elements and their relationships is to describe the money earning logic of the business.To further expand the level of detail, each business model element can be decomposed into a set of sub-elements [34]. All elements and sub-elements, seen in figure 5.3, are formally defined and explained in detail. The definition is summarized in a table for each element/sub-element. The tables are formatted as seen in Table 5.2. Formal definitions of all elements and sub-elements can be found in Appendix A.

In the next chapter the business model will be put to use to make a general model for the FTTH market. Details about the different values that can be assigned to the appropriate attributes will be explained as they occur.

Table 5.1: Business model elements

Pillar	**Business model element**	**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 services 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 in 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.

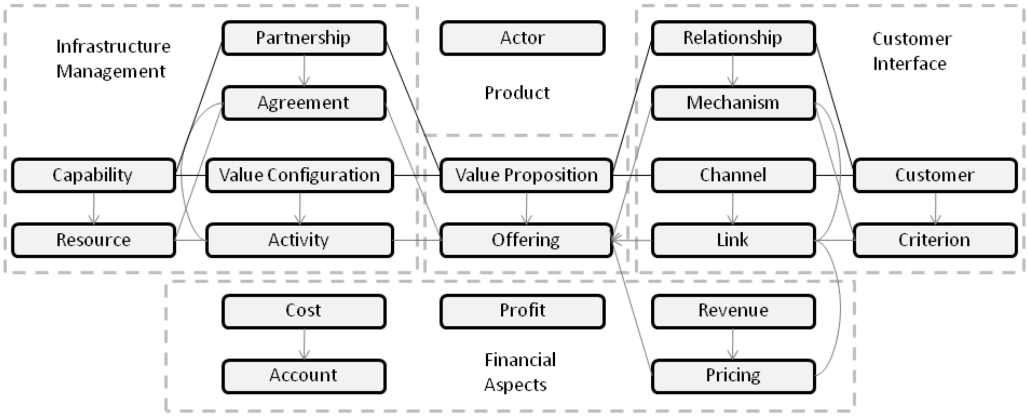

Figure 5.3: Illustration of the Osterwalder Business Model Ontology, as shown in Figure 21 in [34]

Table 5.2: Illustration of how a business model element is described. Based on [34]

Name of BM-Element	NAME
Definition	Gives a precise description of the business model element.
Part of	Defines to which pillar of the ontology the element belongs to or of which element it is a sub-element.
Related to	Describes to which other elements of the ontology an element is related to.
Set of	Indicates into which sub-elements an element can be decomposed.
Cardinality	Defines the number of allowed occurrences of an element or sub-element inside the ontology.
Attributes	Lists the attributes of the element or sub-element. The allowed values of an attribute ar indicated between accolades value1, value2. Their occurrences are indicated in bracets. Each element and sub-element has two standard attributes which are NAME and DESCRIPTION that contain a chain of charactersabc.

Chapter 6

Business Model Analysis

In chapter 4 a macro model was built for the FTTH market. We will now use Osterwalder's ontology, described briefly in chapter 5, to study the market in a micro perspective. We will build a general model for a Network Operator. The Network Operator fills the role of Builder and Service Provider and is defined in chapter 4. We have chosen to analyse the Network Operator because it represents the single point of contact with the customer.

6.1 Actors

In Osterwalder's ontology an Actor is defined as an outside organization that is part of the firm's business model. The Actors are integrated through a Partnership [34]. Based on Chapter 4 we know that the Network Operator does not operate alone. We will therefore begin this chapter by looking at the Actors. The Actor(s) involved in the Network Operator's business model will be the Content Provider(s). The Content Provider(s) are included for their involvement in value creation. As described in chapter 4, the Network Operator would not have much value to the Customer without the Content Provider(s). We will exclude the Content Maker from this analysis as there is no direct cooperation between the Network Operator and the Content Maker.

Table 6.1: The Actors

Actor	Description
Network Operator	The Network Operator manages the physical aspects of FTTH. It is the owner and manager of the access network medium. It is also in charge of setting up and maintaining the service. The Network Operator is the single-point-of-contact for the customer.
Content Provider	The Content Provider is essential to the Network Operators business plan as it provides the services that customers are willing to pay for. In the eye of the Customer the Network Operator and the Content Provider may seem indistinguishable; however, what the Customer wants to buy is the services provided by the Content Provider.

6.2 Product

We will now look at the pillar in Osterwalder's ontology called Product. The Product covers all aspects of what the Network offers to its Customers. The Product pillar is made up of a Value Proposition. Each Value Proposition consists of a set of Offerings. As shown in figure 6.1, the Value Proposition is dependent on the capabilities of the Actors involved in realizing the Product. In our case this will be the Capabilities of the Network Operator and the Content Provider.

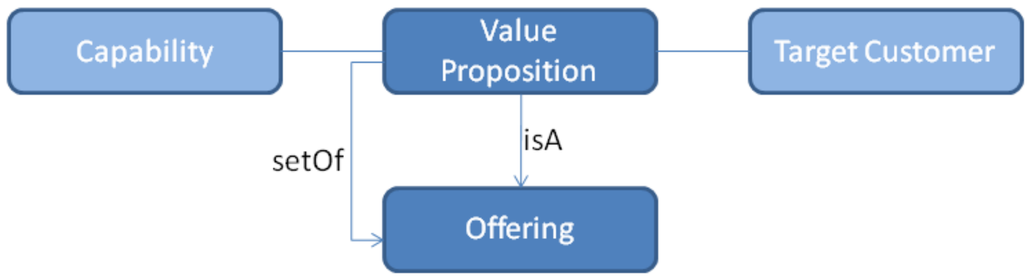

Figure 6.1: Product, based on figure 23 in [34]

6.2.1 Offerings

All Value Propositions are composed of a set of Offerings. The goal of studying the Offerings is for the firm to observe how it positions itself compared to its customers. The Offerings of the Network Provider is listed in table 6.2.

Triple Play is added as an offering here. It could also be viewed as a Value Proposition in itself as it is a bundle of different Offerings. We choose to include it as an Offering as it is offered to the Customer as a single service, and it represents innovation over traditional Network Operators.

Internet

The Offering of Internet services is the first to be discussed here. The service is offered through the partnership between the Network Operator and the Content Provider. The value of the Reasoning attribute is {use} as the value derived from the service by the Customer is through the actual use of the Internet connection. Internet over FTTH is in all essence the same as Internet over any other medium. However, with the use of FTTH technology, the Content Provider is able to provide a symmetric Internet access. By symmetric we mean that the Customer has access to equal upload and download speeds. Though this is possible over other access mediums, it is not common. We will therefore view this as an innovative element added to an imitated offering and the value of the Value Level attribute is thus {Innovative imitation}.

The Price Level of Internet over FTTH does not differ significantly from Internet over other mediums. This statement is based on price information taken from NetGenTel's web pages [35, 36]. The author chose NextGenTel as an example as they offer Internet connection over different mediums, including fibre. If we look at a second actor, Malvik Fiber [37], we see that they are priced slightly higher than NextGenTel, but this is not considered by the author to be a significant difference. The value of the Price Level attribute is thus {Market}. Value for the Customer from the Internet service is derived through the use of it. The value of the Life Cycle attribute is thus {Use}.

Phone

The second Offering by the collaboration of Network Operator and Content Provider is Telephone services. The Telephone service creates value for the Customer through use, thus the value of the Reasoning attribute is {Use}. A Telephone connection over FTTH is not differentiated from ordinary Telephone services in any way in terms of value offered to the user. The Value Level attribute thus has the level {Me-too}. In terms of pricing, we have chosen to compare Telephone services over FTTH with other Telephone services over different broadband services. The Price Level attribute is set to {Market} based on NextGenTel and Malvik Fiber [36, 37, 38]. The Life Cycle attribute for the Telephone service is also set to {Use}.

Television

The Television Offering is the third Offering to the Customer. This offering, as the two previous Offerings, aims to give the Customer value through the use of the Offering. The Reasoning attribute thus has the value {Use}. The Offering is not differentiated from traditional Television Offerings at this point. The Value Level is thus {Me-too}. The pricing of the Television service depends on which channels the Customer opts to subscribe to. The pricing of channels depends on the type of channel (e.g. Movie channel, sports channel, etc.). The Price Level attribute is set to {Market}. This is a reasonable assumption based on several Television providers' web pages [36, 37, 39, 40, 41]. Finally, the Life Cycle attribute is set to {Use} as in the previous Offerings.

Triple Play

The introduction of 3P may indeed simplify the life of the User. Instead of having one Internet provider, one phone operator and one television provider, this can all be managed through a single point of contact. The simplification does in no way represent a lowering of quality; rather it gives a higher quality. The Reasoning attribute thus gets the value {Effort} for the 3P Offering.

Table 6.2: The Offerings

Offerings	**Internet**	**Phone**	**Television**	**Triple Play**
Description	A connection obtained over the FTTH network provides the user with an Internet service.	The FTTH network is used as a medium for phone services.	Television signals are transmitted over the FTTH network.	The three aforementioned services are bundled to provide the Customer with a simpler solution; all services from the same provider over one interface.
Reasoning	{Use}	{Use}	{Use}	{Effort}
Value Level	{Innovative imitation}	{Me-too}	{Me-too}	{Innovation}
Price Level	{Market}	{Market}	{Market}	{Market}
Life Cycle	{Use}	{Use}	{Use}	{Use}

The bundling of the services also represents an innovative simplification. The Value Level is thus set to {Innovation}. We already concluded that the Price Level for Internet, Telephone and Television have Price Levels of {Market}. Based on [36, 37] we thus set the Prise Level of 3P to {Market}. The Life Cycle of 3P will follow the Life Cycle of the three other Offerings and is thus set to {Use}. A summary of the discussion made here is found in table 6.2.

6.2.2 Value Proposition

The Value Proposition is composed of a set of Offerings. In this case, the Offerings discussed above. The Value Proposition itself is the Provision of FTTH access. The Value Proposition Element is described in table 6.3. The Target Customer will be discussed in section 6.3.1 and the capabilities will be discussed in section 6.4.2. The connection between the Capabilities, Value Proposition and Target Customer(s) is illustrated in figure 6.2.

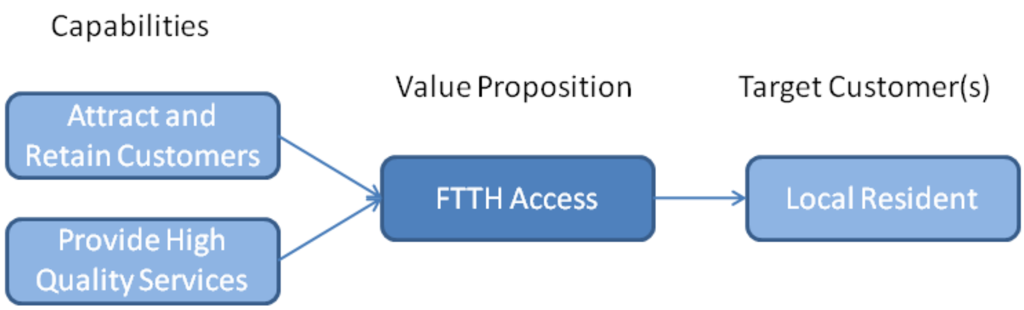

Figure 6.2: Connection between Capabilities, Value proposition and Target Customers

6.3 Customer Interface

The second pillar in the Osterwalder Ontology is the Customer Interface. The Customer interface includes the elements Relationship, Distribution Channel and Target Customer and their sub elements. The Customer Interface is defined by Osterwalder to include every aspect related to the customer. In the

Table 6.3: Value Proposition Element

Value Proposition: FTTH Access
Description: The main Value Proposition of the Network Operator and its partner the Service Provider is to deploy FTTH access to their target customers. This Value Proposition will enable the target Customers to access high quality services and Triple Play in particular.
Reasoning: {Use}
Value Level: {Innovation} The combined services that can be provided via the FTTH access Value Proposition can not be rivalled by competing actors.
Price Level: {Market}
Composed of Offerings:
- Internet
- Phone
- Television
- Triple Play
Value for Target Customer:
- Local Residents
Based on Capabilities:
- Attract and Retain Customers
- Provide High Quality Services

bigger picture the Customer Interface describes how the Value Proposition is delivered to the Customer, who the customer is and what kind of relationship the firm wishes to have to the customer [34]. The Customer Interface is illustrated in figure 6.3.

Osterwalder focuses largely on marketing and the use of ICT to manage Customers [34]. We have previously discussed how the Content Provider is the Actor in possession of the services that a Customer will be willing to buy. Because of this the Network Provider in our model will rely on the Content Provider for marketing. Marketing will thus be excluded from our discussion of Distribution Channel and Links.

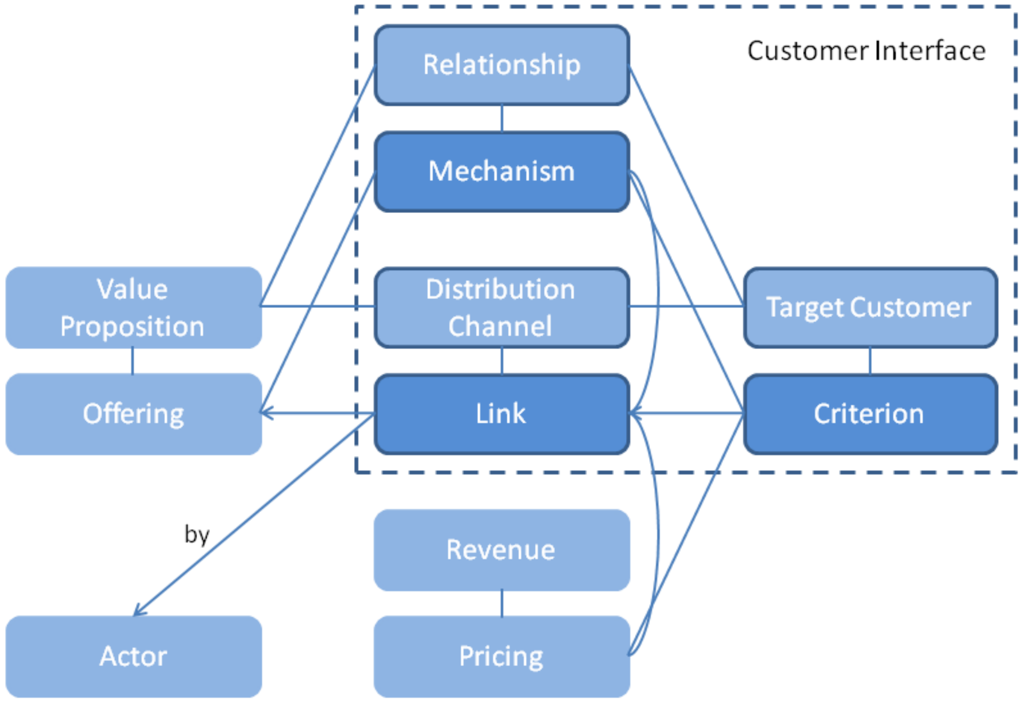

Figure 6.3: The Customer Interface. Based on figure 29 and 31 in [34].

6.3.1 Target Customer and Criterion

When discussing FTTH as in this thesis, there is no fuss over who are the Target Customers. The nature of FTTH is one-to-one, meaning that each stretch of fibre built, provides access to one home. The Target Customer thus becomes the people living in homes in areas where the Network Operator chooses to build, in other words; local residents. This represents a business-to-consumer (B2C) relationship. We choose to exclude local businesses here as we are using a strict interpretation of FTTH (to the *home*). The Target Customer element is summarized in table 6.4.

Table 6.4: Target Customer Element

Target Customer: Local Resident
Description: Local Residents living in a home within the area where the Network Operator chooses to deploy fibre access network.

6.3.2 Distribution Channel and Link

The Distribution Channel is the channel through which a firm distributes its Value Proposition to its Target Customers. As previously mentioned we will exclude marketing from this discussion. The Value Proposition of the Network Operator consists of the different services that the Content Provider offers the Customer. The Value Proposition is distributed to the Customers through the Fibre link. This is the only Distribution Channel that the Network Operator has. The Distribution Channel element is defined in table 6.5. Figure 6.4 shows an illustration of the connection between the Value Proposition, Distribution Channel and Target Customer. We choose to use the attribute Value Life Cycle instead of Customer Buying Cycle as it is more relevant to our kind of Link.

Table 6.5: Distribution Channel Element

Distribution Channel: Fibre Link
Description: The Fibre link is the distribution Channel used by the Network Operator to deliver its Value Proposition to the Target Customers.
Life Cycle: {Use} - The customer derives value through the use-phase of the Life Cycle.
Composed of Link:
- Fibre link. This is the only link in the Distribution Channel that is relevant to the Network Operator.

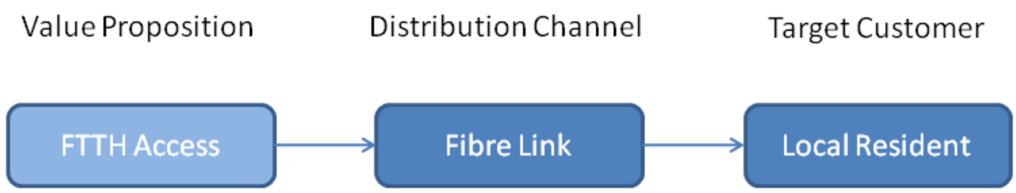

Figure 6.4: Connection between Value Proposition, Distribution Channel and Target Customer.

6.3.3 Relationship and Mechanism

The last element of the Customer Interface is the Relationship Element. It has one sub element; the Mechanism. The Relationship element concerns the relationship that the firm builds and maintains with its customer. The different mechanisms are used to acquire and retain the target customers [34]. As mentioned in the previous section the Network Operator leaves the marketing to the Content Provider. The Network Operator will, based on the same reasons as above, also leave customer acquisition and retention largely to the Content Provider. However, the actions of the Network Operator will influence the Content Providers relationship with the customer. The relationship that the Network Operator will have to maintain is the Fibre link.

In the current FTTH market, we don't see many Network Operators offering services in the same locations. As discussed in section 4.2 the Network Operator is often a local electricity provider. These providers tend to stay local. As there is no real competition in each location between different Network Operators, the Network Operators can focus on acquiring new customers over retaining the ones they already have. Thus the Customer Equity value is set to {Acquisition}. The Life Cycle attribute is set to{use}; value for the customer is derived though use of the provided services. For the Content Provider to be able to deliver its services in a satisfactory way, the fibre link needs to be reliable. The Function attribute is thus set to {Trust}. The Network Operator needs to build trust.

Table 6.6: Relationship Element

Relationship: Fibre link
Description: The Fibre link will affect the relationship between the customer and both Network Operator and Content provider.
Customer Equity: {Aquisition}
Value Life Cycle: {Use}
Function: {Trust}
Composed of Mechanisms:
- Fibre link

6.4 Infrastructure Management

The Infrastructure Management pillar consists of the elements Capability, Partnership and Value Configuration and their sub elements. The pillar is built around how a business earns its money. The Pillar indicates what abilities are necessary to provide the business's Value Proposition and to maintain its Customer Interface [34].

A business may not possess all the Capabilities it needs to perform the activities necessary to provide the Value Configuration. If this is true, the business should enter a Partnership of some sort. In our model this is exactly the case; both Network Operator and Content Provider depends on the other's Capabilities. This section will explain the aspects of this Partnership, the Capabilities that the partnership presides over and the Value Configuration produced. The Infrastructure Management pillar is illustrated in figure 6.5.

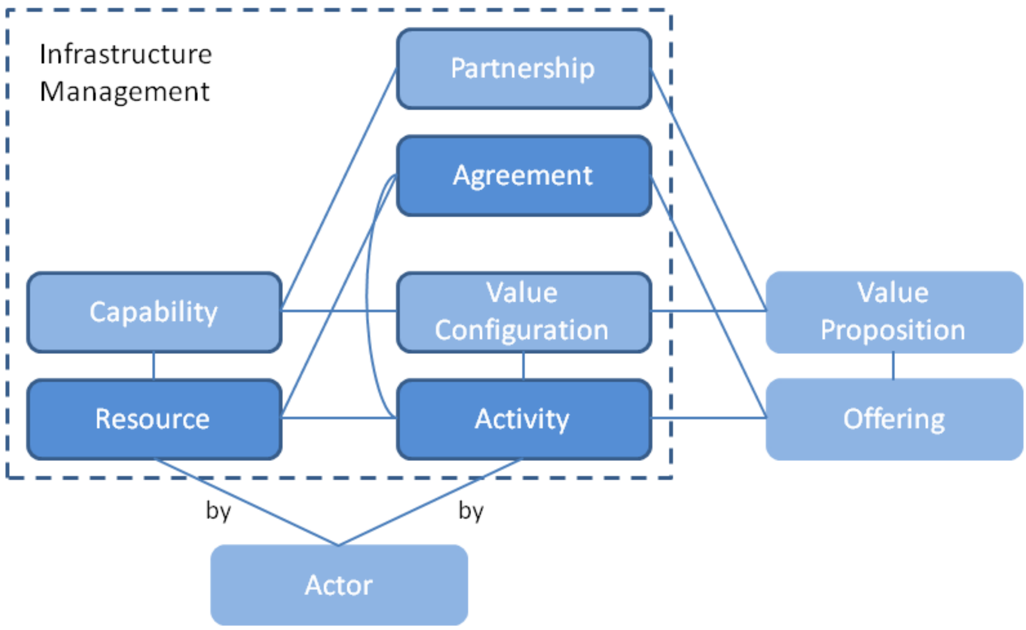

Figure 6.5: The Infrastructure Management. Based on figure 39, 40 and 42 in [34].

6.4.1 Partnership and Agreement

The first element to be discussed within the Infrastructure element is the Partnership element. By Osterwalder's definition a Partnership is a cooperation between two or more firms that is initiated voluntarily. The two firms share the necessary capabilities and resources to carry out a specific project or task. All Partnerships are entered into to provide a Value Proposition [34].

Each Partnership is defined by the sub element Agreement. However the Agreement element is very specific and subjective. As we are now building a generic model for a generic Network Operator, we will not define the Agreement element further in this text.

A Network Operator may have partnerships with several types of actors, but the most important one to our discussion is the Partnership with the Content Provider. The Network Operator and the Content Provider join together to form the Value Proposition discussed in section 6.2.2. As discussed in chapter 4.2, the Network Operator may have a Partnership with one or several Content Providers. The specifications of one such Partnership is listed in table 6.7.

6.4.2 Capabilities and Resources

A set of Capabilities are needed for the Network Operator to be able to offer its Value Proposition. Each Capability is defined as the ability to execute a repeatable pattern of actions. Each Capability is based on a set of Resources acquired by the Network Operator alone or in partnership with an other Actor [34]. This section will describe the Resources and Capabilities that the Network operator needs to obtain to be able offer the Value proposition discussed in section 6.2.2. Resources are described in table 6.8 and capabilities in table 6.9 and 6.10.

Table 6.7: Partnership Element

Partnership: Content Provider Partnership
Description: To provide the Customer with an attractive Value Proposition, the Network Operator needs to enter into a Partnership with a Content Provider. The two Partners then co-produce the value offered to the Customer.
Reasoning: {Aquisition of Resources}: The Content Provider contributes with vital parts of the Value Creation. The Content Provider is the Actor contributing with the services that the Customer wants to buy.
Strategic Importance: 5 - these kinds of Partnerships are strategically vital to the Network Operator. Without them they would have little value to sell to the Customer.
Degree of Competition: 0-1 - The degree of competition between the Network Operator and the Content Provider is virtually non-existing. They contribute to different parts of the Value Creation.
Degree of Integration: 3 - There is not much integration of the two partners in terms of services offered. However, as the Customers single-point-of-contact, the Network Operator is in charge of the Customer base, and this leads to some integration.
Substitutability: 4-5 - Based on the discussion in section 4.2 we can conclude that it would be relatively easy for the Network Operator to substitute one Content Provider for another.

6.4.3 Value Configuration and Activity

The last element of the Infrastructure Management Pillar is the Value Configuration. The Value Configuration describes how a set of Activities are performed to create a Value Proposition. All Activities are in turn connected to one or several Resources [34]. This section will describe the activities performed by the Network Operator and the Content Provider to build their Value Proposition. It will also arrange the Activities into the Value Configuration.

Table 6.8: Resources

Resource	Description	Resource Type	Provided by
Fibre link	The physical access link to each Customer	{Tangible}	Network Operator
Customer Base	The pool of connected Customers	{Tangible}	Network Operator
Content	The value creating services	{Tangible}	Content Provider
Brand Name	A good brand name may attract Customers	{Intangible}	Content Provider, Network operator
Deployment Experience	The know-how on how to deploy and manage fibre	{Intangible}	Network Operator
Customer Knowledge	Knowledge about customers, what they want	{Intangible}	Network Operator, Content Provider

Table 6.9: Capability; Customer attraction and retention

Capability: Attract and Retain Customers **Description:** Without Customers it is impossible to do business. A firm needs to be able to attract and retain Target Customers. **Composed of Resources:** - Customer Knowledge - Brand Name - Customer Base

Table 6.10: Capability; Provide High Quality Services

Capability: Provide High Quality Services **Description:** The capability to deliver High Quality services to all Customers. **Composed of Resources:** - Fibre link - Content - Deployment Experience

Table 6.11: Activities

Activity	Description	Connects to Resource(s)	Activity Level	Activity Nature
Deploy Network	Deploy the access network	Deployment Experience	{Primary}	{Network Infrastructure Operation}
Manage Network	Management, monitoring and maintenance	Deployment Experience, Fibre link	{Primary}	{Network Infrastructure Operation}
Selling	Selling solutions to the Customer	Customer Base, Content, Brand Name	{Primary}	{Service Provisioning}
Manage Customers	Manage suscriptions and billing	Customer Base, Customer Knowledge	{Primary}	{Network promotion and contract management}
Manage Content	Manage the contentthat is to be provided to customers.	Content	{Primary}	{Service provisioning}

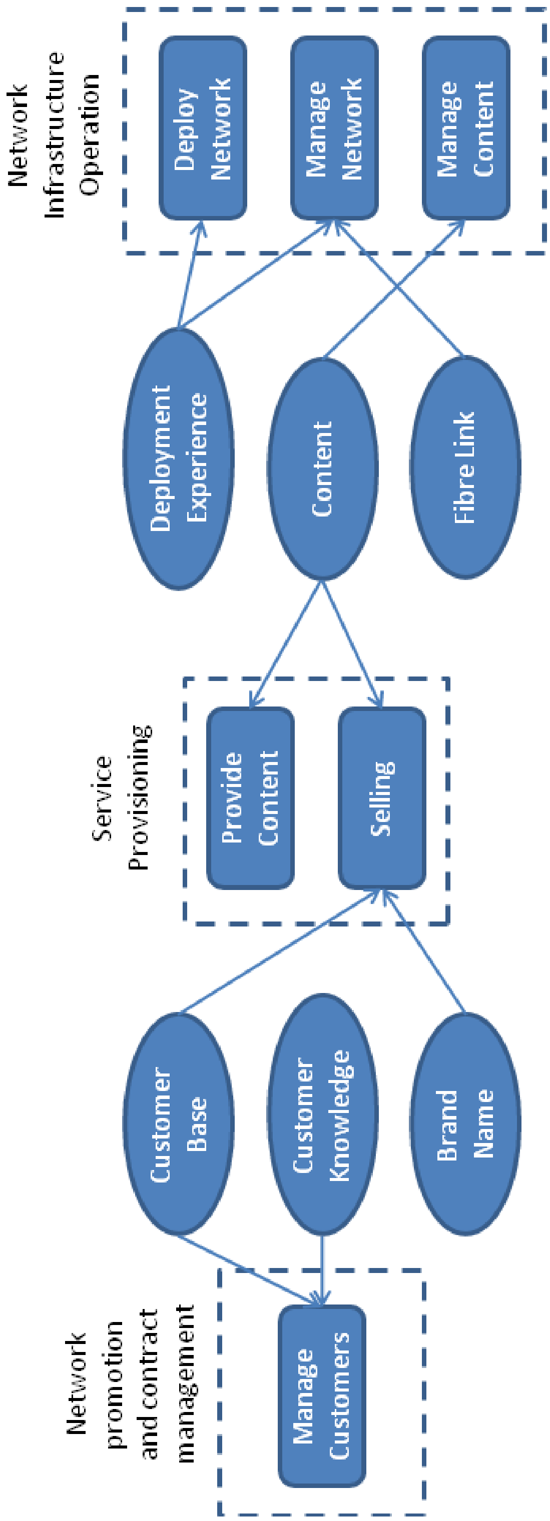

Figure 6.6: Activities and Resources organized into the Value Configuration as a Value Network

6.5 Financial Aspects

The final Pillar in Osterwalder's Ontology is the Financial Aspects. It consists of the two elements Revenue Model and Cost Structure. They each have a sub element; Revenue Stream & Pricing and Account, respectively. Together, these elements determined the profit- or loss-making logic of the firm. Ultimately this tells whether the firm will survive or not [34]. A illustration of the Financial Aspect Pillar is found in figure 6.7.

In this section we will look mainly at the Revenue Model of the Network Operator. A possible Revenue Model will be presented. However, we bear in mind that several different configurations are possible; this is not a complete blueprint. We will not focus on the Cost Structure here; we will simply mention some of the most important costs a Network Operator will have.

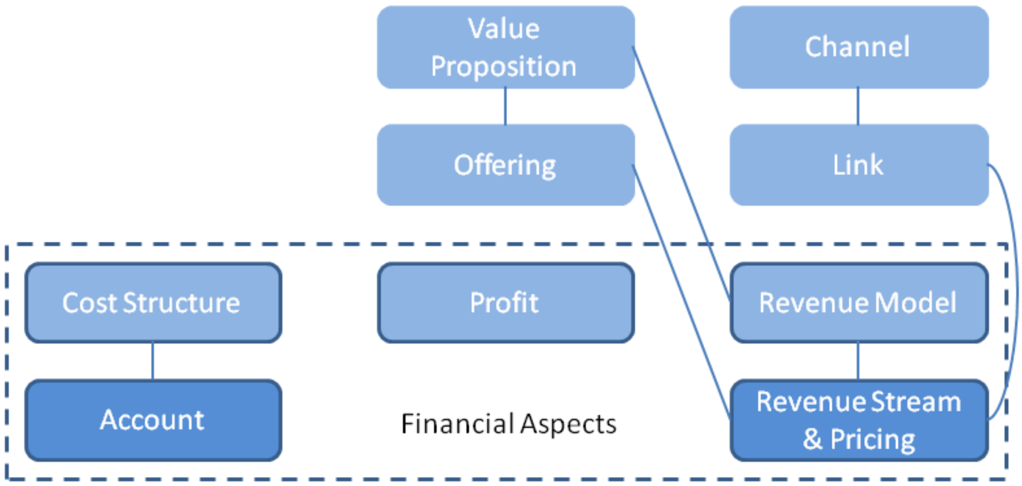

Figure 6.7: The Financial Aspect

6.5.1 Revenue Model

The Revenue Model describes how a firm turns its services into revenue. The revenue Model can be further decomposed into Revenue Streams. Any given firm will have one or more incoming Revenue Streams. Each Revenue Stream will have its own pricing mechanism [34].

In the case of our Network Operator, as modelled in section 4.2, there is really only one incoming stream of revenue. This stream comes directly from the Customer. This revenue stream is the payment from the Customer for all services purchased, the Customer Fee. The Network Operator will keep its share of the revenue and distribute the rest to the appropriate Content Provider(s). The Revenue Stream is defined in table 6.12

Table 6.12: Revenue Stream and Pricing

Revenue Stream and Pricing	**Customer Fee**
Description	The Customer Fee is fees paid by the Customer for all services purchased.
Related to Offering, Link	For Offering: FTTH access From Link: Fibre link
Stream Type	{Lending}: The actual link is still owned by the Network Operator. The Customer has merely paid to use it for a period of time.
Percentage	100%
Pricing Method	{Fixed Pricing}

6.5.2 Cost Structure

As the Cost Structure will be different for each Network Operator, the Cost Structure Onotology element will not be defined here. General costs have already been discussed in Chapter 4.

Chapter 7

Discussion

7.1 The impact of technology on Profitability

In this thesis, several technical choices for a FTTH network have been presented. We have also reviewed investment analyses, highlighting how investment cost changes based on what kind of network is deployed and where it is deployed. Profit, by definition is revenue-cost [42, page 74]. Cost naturally refers to all cost and investment cost alone does not define the profit. All cost has to be taken into consideration. Running cost is difficult to estimate and businesses are not very willing to grant outsiders insight into it.

Based on the previous chapters, it is clear that the question of profitability and technology boils down to one issue; active or passive network. There is no doubt that both network solutions suffer from the same high deployment cost as the major part of the initial investment is spent on digging. There might be a small difference in how many meters of ditches you have to dig, but this is probably not the difference that will determine your profitability. Also, there is no real difference in the income you can generate from an active and a passive solution. The services delivered over them are the same so there is no room for price differentiation between the different actors. The last factor to come into play here is this; running cost and maintenance.

The network solution with the lowest possible running cost will probably be the first to generate profit for its owners and investors. First of all; as already stated, running cost is the most difficult cost to gain insight into. Secondly; very few actors in the Norwegian market have opted for the passive solution, making it increasingly difficult to form a basis for comparison.

The author believes that PON will eventually enter the Norwegian FTTH market to a larger extent than today, with Telenor as a forerunner. Skavdal showed that a PON network is more economically suited in highly populated areas in terms of investment cost[Referanse her.. til seksjon eller kilde?]. If several operators act on this and deploy passive networks in highly populated areas, they may find that there are more benefits to a passive network than meets the eye. They will also gain experience and knowledge on PONs. These factors may, together, shift the focus of the builders over to PON. In the opinion of the author, profitability will slowly follow this shift.

7.2 The Impact of Business Models on Profitability

In section 4.2 several collaboration forms in the Norwegian FTTH market were described and modelled. Regardless of the business model; investment costs are high and the revenues are somewhat limited by the customers willingness to pay. Based on the arguments already made in this thesis we now propose that the model that has the greatest influence on profitability is the Franchise model Altibox.

When discussing the technology impact on profitability we proposed that a shift towards building of PON networks would improve profitability. The Altibox model does not have a positive impact on profitability, but a negative one. The model requires an underlying network technology of active networks. In other words; the Altibox model is hindering the shift towards passive networks, and thus keeping profitability low.

We propose that the Altibox model will me less important in a few years and that the Open Access model will grow. Customers are probably willing to pay to have several choices available to them, making Altibox a limiting model.

7.3 Future Outlook

Throughout the process of writing this thesis there has been constant mentioning of FTTH deployment in the Norwegian media. Most recently there has been a debate about an upcoming alteration in the Norwegian law for roads. The Directorate for Public Road Administration proposed an alteration that would set higher standards for deployment. Some roads will inevitably have to be dug up to lay fibre. The higher density population in the area of deployment, the more digging affecting roads will be necessary. The initial intention of the proposal was to ease the progress of deployment. The result however would probably have been the opposite. The new law proposal would have set higher standard for the builders. In the regulation there was a demand for deeper and wider ditches and a substitution of the earth mass [43].

It was claimed that the new regulation, if adopted, would increase cost of deployment by a staggering 300 to 900% [44]. In a situation where digging related to deployment is already the majority of costs, this is bad news. Fortunately for the Norwegian FTTH industry, the Ministry of Transport and Communications stepped in and stopped the law alteration. The Directorate of Public Road Administration has dismissed the entire proposal and will start working on a new one. The work is performed in cooperation with industry actors and has the same initial intention; ease the deployment [45].

The new proposal will most likely incorporate and allow the use of a new technique, where ditches are not needed. Instead of ditches, a small track is made in asphalt, a decimetres deep, in which fibre is deployed [45]. As this process eliminates much of the digging, huge amounts of money can be saved.

This discussion was included here to show that things are happening on several levels to ease the deployment of fibre in Norway. The industry is thinking of alternative ways to deploy fibre in order to reduce cost. Also new technology is constantly being researched and Telenor's deployment of PON will possibly set a new standard. Government institutions try to help the industry by adapting laws and regulations that will facilitate deployment.

The author believes that the progress illustrated above will eventually lead to better profitability prospects than what we see today.

Chapter 8

Conclusion

This Thesis has reviewed several aspects of the FTTH market. It has looked at available technologies and the investment cost connected to them. The FTTH market in Norway has also been looked at from several angles; what drives it, who are the actors within it and how do these actors operate and relate to each other.

We have found that the profitability in the industry is dependent on the technology chosen and that in the coming years we will probably see a shift in what technologies are being deployed. Also the techniques for deploying fibre is being researched and tested. These technical changes are likely to positively influence profitability in the market.

When it comes to business models, we have found that they influence profitability in a more indirect way, as they to some extent control the technology choices. We predict that this will change. The models will shift towards Open Access and free choice of services for the customers. The shift towards Open Access will most likely help to improve profitability in the Norwegian FTTH market.

Bibliography

[1] Josep Prat, Carlso Bock, Jose A. Lazaro, Victor Polo, Fabio Neri, Christina Arellano, Ton Koonen, Gerard Franzl, Jorge M. Finchietto, and Philippe Chanclou, *Next-Generation FTTH Passive Optical Networks*, Springer Netherlands, Netherlands, 2008.

[2] The FTTH Council Europe, "Ranking of european ftth penetration shows scandinavia and smaller countries still ahead", `http://www.ftthcouncil.eu/documents/press_release/PR_EU_rankings_Final.pdf`, 2009.

[3] Nexia International, "Gevinster av høykapasitets bredbåndsnett i distrikts-norge", 2010.

[4] Norsk Telecom AS, "Fibermarkedet - "butikk eller politikk"", `http://www.teleinfo.no/?id=52`, 2010, Summary of the report itself.

[5] Jonas Blich Bakken, "Pris per kunde: 30.000 kroner", `http://www.dagensit.no/k/bredband/article1818518.ece`, Published 18.01.2010.

[6] Bente Bjørndal, "Er dette verdens dyreste bredbånd?", `http://www.dagensit.no/article1817903.ece`, Published 18.01.2010.

[7] Maurice Gagnaire, "An overview of broad-band access technologies", *Proceedings of the IEEE*, vol. 85, no. 12, pp. 1958 –1972, dec 1997.

[8] Claude E. Shannon, “A mathematical theory of communication”, *The Bell System Technical Journal*, vol. 27, pp. 379–423, 623–656, July, October 1948.

[9] Telecommunication Standardization Sector of ITU, *Very high speed digital subscriber line foundation - ITU-T Recommendation G.993.1*, 2001.

[10] Ton Koonen, “Fibre-optic techniques for broadband access networks”, *Telektronikk*, vol. 2005, no. 2, pp. 49 – 65, 2005.

[11] Josep Prat, Pere E. Balaguer, Joan M. Genè, Oscar Díaz, and Sergi Figuerola, *Fiber-to-the-Home Technologies*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2002.

[12] KEYMILE, *AON vs. PON - A comparison of two optical access network technologies and the different impact on operations*, 2008.

[13] Eugene Edmond, Kent Mccammond, Renee Esties, and Julie Lorentzen, “Today’s broadband fiber access technologies and deployment considerations at sbc”, in *Broadband Optical Access Networks and Fiber-to-the-Home*, Chinlon Lin, Ed. Wiley, 2006.

[14] Thomas Jelle, “Fremtidens informasjonsforsyning - modeller for fiberrealiseringer”, Master’s thesis, Norwegian University of Science and Technology, 2004.

[15] Altibox, “Altibox litt magi, resten teknologi”, `http://www.altibox.no/omaltibox/historien`, Last visited 22.06.2010.

[16] Bjørn Tore Paulen, ”, Email correspondence with Eidsiva Bredbånd, 15.06.2010.

[17] Jørn-Håvard Olsen, ”, Email correspondence with Signal Bredbånd, 11.06.2010.

[18] Guttorm A. Hansen, “Utviklingen av aksessnettet - fra kobber til radio og fiber - telenors tanker om aksessnettet”, Presentation.

[19] David Payne, Russel Davey, David Faulkner, and Steve Hornung, "Optical networks for the broadband future", in *Broadband Optical Access Networks and Fiber-to-the-Home*, Chinlon Lin, Ed. Wiley, 2006.

[20] Lawrence G. Roberts, "Beyond moore's law: Internet growth trends", *Computer*, vol. 33, pp. 117–119, 2000.

[21] Kilho Song and Yong-Kyung Lee, "Broadband access networks and services in korea", in *Broadband Optical Access Networks and Fiber-to-the-Home*, Chinlon Lin, Ed. Wiley, 2006.

[22] Russell Davey, Jose A Lazaro, Reynaldo Martínez, Joseph Prat, and Raul Sananes, "Economic models", in *Next-Generation FTTH Passive Optical Networks*, Joseph Prat, Ed. Springer Netherlands, 2008.

[23] Statistics Norway, "Still slow growth in the mainland economy", `http://www.ssb.no/english/subjects/09/01/knr_en/`, 2010, Last visited 22.06.2010.

[24] Bjørnar Skavdal, "Lønnsomhetsanalyse - realisering av fiberoptiske aksessnett", Master's thesis, University of Agder, 2009.

[25] Don Daszkowski, "What is a franchise?", `http://franchises.about.com/od/franchisebasics/a/what-franchises.htm`, Last visited 22.06.2010.

[26] Altibox, "Leverandører", `http://www.altibox.no/omaltibox/leverandorer`, Last visited 22.06.2010.

[27] Altibox, "Bli partner", `http://www.altibox.no/omaltibox/bli-partner`, Last visited 22.06.2010.

[28] Telenor, "Telenor går for fiber", `http://www.telenor.no/privat/internett/tipsognyheter/fiber.jsp`, Last visited 22.06.2010.

[29] ByNett, "Medlemmer", `http://www.bynett.no/page1029497.aspx`, Last visited 22.06.2010.

[30] Bynett, “Om foreningen”, `http://www.bynett.no/OmBynett.aspx`, Last vistited 22.06.2010.

[31] Norsk Fibernett, “Om oss”, `http://www.norskfibernett.no/index.jsp?ref=article.jsp&kilde=omoss`, Last visited, 22.06.2010.

[32] NextGenTel, “Bredbånd over fiber”, `http://www.nextgentel.no/privat/bredband/fiber/`, Last visited 22.06.2010.

[33] Joan Magretta, “Why business models matter”, *Harvard Business Review*, may 2002.

[34] Alexander Osterwalder, *The Business Model Onthology - A Proposition in a Design Science Approach*, PhD thesis, Université de Lausanne, 2004.

[35] NextGenTel, “Next3 bredbånd”, `http://www.nextgentel.no/privat/bredband/abonnement/next3/`, Last visited 22.06.2010.

[36] NextGenTel, “Produkter og priser”, `http://www.nextgentel.no/fiber/kvam/produkter.php`, Last visited 22.06.2010.

[37] Malvik Fiber, “Priser”, `http://malvikfiber.no/priser.html`, Last Visited:22.06.2010.

[38] NextGenTel, “Bredbåndstelefon - bedre og billigere”, `http://www.nextgentel.no/privat/telefon/`, Last visited 22.06.2010.

[39] NextGenTel, “Tv”, `http://www.nextgentel.no/privat/tv/`, Last visited 22.06.2010.

[40] get, “Våre kanalpakker”, `http://get.no/web/produkt/digitalTV/Kanalside`, Last visited 22.06.2010.

[41] Viasat, “Folkepakke”, `http://www.viasat.no/Programpaket/Viasat-Folkepakke.html`, Last visited 22.06.2010.

[42] David Begg, Stanley Fischer, and Rudiger Dornbusch, *Economics*, McGraw-Hill, 2003.

[43] Espen Zachariassen, “Staten sin egen største fiende”, `http://www.tu.no/it/article237255.ece`, Published 18.02.2010.

[44] Espen Zachariassen, “Utbyggingen stopper opp”, `http://www.tu.no/it/article249966.ece`, Published 23.06.2010.

[45] Espen Zachariassen, “Stopper hele forskriften”, `http://www.tu.no/it/article250094.ece`, Published 24.06.2010.

Appendices

Appendix A

Business Model Elements

Table A.1: Value Proposition

Name of BM-Element	**Value Proposition**
Definition	A VALUE PROPOSTITION represents value for one or several TARGET CUSTOMER(s) and is based on one or several CAPABILITY(ies). It can be further decomposed into its set of elementary OFFERING(s). A VALUE PROPOSITION is characterized by its attributes DESCRIPTION, REASONING, VALUE LEVEL and PRICE LEVEL and an optional LIFE CYCLE.
Part of	Product
Related to	*Value for* Target Customer *Based on* Capability (1-n)
Set of	Elementary Offering(s) (0-n)
Cardinality	1-n
Attributes	Inherited from elementary Offering

Table A.2: Offering

Name of BM-Element	**Offering**
Definition	An elementary Offering is a part of an overall Value Proposition. It is characterized by its attributes Description, Reasoning, Life Cycle, Value Level and Price Level.
Element of	Value Proposition
Cardinality	0-n
Attributes	Name {abc} Description {abc} Reasoning {Use, Risk, Effort} (0-n) Value Level {Me-Too, Innovative Imitation, Excellence, Innovation} Price Level {Free, Economy, Market, High-End} Life Cycle {Creation, Purchace, Use, Renewal, Transfer}

Table A.3: Target Customer

Name of BM-Element	**Target Customer**
Definition	A Target Customer segment defines the type of customer a company wants to address.
Part of	Customer Interface
Related to	*Receives* a Value Proposition (1-n)
Set of	Criterion(s) (0-n)
Cardinality	1-n
Attributes	Inherited from Criterion

Table A.4: Criterion

Name of BM-Element	**Criterion**
Definition	A Criterion defines the characteristics of a Target Customer.
Part of	Target Customer
Cardinality	0-n
Attributes	Name {abc} Description {abc}

Table A.5: Channel

Name of BM-Element	**Channel**
Definition	A distribution Channel describes how a company *delivers* a Value Proposition to a Target Customer segment. Normally a firm disposes of one or several direct or indirect Channel(s) that can be decomposed into their Link(s).
Part of	Customer Interface
Inherits from	Link
Related to	*Delivers* Value Proposition (1-n) *Delivers to* Target Customer (1-n)
Set of	Link(s) (0-n)
Cardinality	1-n
Attributes	Inherited from Link

Table A.6: Link

Name of BM-Element	**Link**
Definition	A channel Link is part of a Channel and describes a specific channel role. It may be part of the Value Proposition and it may be related to another Link.
Element of	Channel (1-n)
Inherits from	Offering
Related to	A Link can be *connected to* an other Link (0-n) The channel role described by a channel Link is *delivered by* an Actor (0-n)
Cardinality	0-n
Attributes	Inherited from Offering Customer Buying Cycle {Awareness, Evaluation, Purchase, After Sales} (Overwritten by Value Life Cycle if the Link is also an Offering)

Table A.7: Relationship

Name of BM-Element	**Relationship**
Definition	The Relationship element describes the relationship a company establishes with a Target Customer segment. A Relationship is based on customer equity and can be decomposed into several Relationship Mechanisms.
Part of	Customer Interface
Inherits from	relationship Mechanism
Related to	A Relationship promotes a Value Proposition (1-n) A Relationship is maintained with a Target Customer (1-n)
Cardinality	1-n
Attributes	Customer Equity {Aquisition, Retention, Add-On Selling} All other attributes are inherited from the relationship Mechanism

Table A.8: relationship Mechanism

Name of BM-Element	**relationship Mechanism**
Definition	A Relationship Mechanism is part of a Relationship and describes the function it accomplishes between the company and its customers. It may also be a channel Link or a part of the Value Proposition.
Element of	Relationship
Inherits from	Link
Cardinality	0-n
Attributes	Inherited from Link Function {Personalization, Trust, Brand}

Table A.9: Capability

Name of BM-Element	**Capability**
Definition	A Capability describes the ability to execute a repetable pattern of actions. A firm has to dispose of a number of Capabilities to be able to offer its Value Proposition. Capabilities are based on a set of resources from the firm or its partners.
Part of	Infrastructure Management
Related to	A Capability(ies) allows a firm *to provide* its Value Proposition (0-n)
Set of	Resource(s) (0-n)
Cardinality	1-n
Attributes	Inherited from Resource

Table A.10: Business model Actor

Name of BM-Element	**Actor**
Definition	A business model Actor is an outside organization that is involved in the firm's business model an is integrated through a partnership.
Attributes	Name {abc} Description {abc}

Table A.11: Resource

Name of BM-Element	**Resource**
Definition	Resources are inputs into the value-creation process. They are the source of the Capabilities a firm needs in order to provide its Value Propositions.
Element of	Capability (1-n)
Related to	A Resource can be provided *by* an Actor (0-n) A Resource *{fits}, {flows}, to or is {shared}* by one or several Activities (0-n)
Cardinality	0-n
Attributes	Name {abc} Description {abc} Resource Type {Tangible, Intangible, Human}

Table A.12: Value Configuration

Name of BM-Element	**Value Configuration**
Definition	The Value Configuration of a firm describes the arrangement of one or several Activity(ies) in order to provide a Value Proposition.
Part of	Infrastructure Management
Related to	The Value Configuration relies on a set of Capabilities (1-n) The Value Configuration makes Value Propositions possible (1-n)
Set of	Activity(ies)
Cardinality	1-n
Attributes	Configuration Type {Value Chain, Value Shop, Value Network} Other attributes inherited from Activity

Table A.13: Activity

Name of BM-Element	**Activity**
Definition	An Activity is an action a company performs to do business and achieve its goals.
Element of	Value Configuration
Related to	An Activity is *executed by* an Actor (1-n) An Activity *{fits}, {flows} to or is {shared}* by one or several Resources(s) (0-n)
Cardinality	0-n
Attributes	Name {abc} Description{abc} Activity Level {Primary Activity, Support Activity} Activity Nature (0-1) • for Value Chain {Inbound Logistics, Operations, Outbound Logistics, Marketing and Sales, Service} • for Value Shop {Problem Finding and Aquisition, Problem Solving, Choice, Execution, Control and Evaluation} • for Value Network {Network Promotion and Contract Management, Service Provisioning, Network Infrastructure Operation}

Table A.14: Partnership

Name of BM-Element	**Partnership**
Definition	A Partnership is a voluntarily initiated cooperative agreement formed between two or more independent companies in order to carry out a project or specific activity jointly by coordinating the necessary Resources and Activities.
Part of	Infrastructure Management
Related to	Concerns a Value Configuration (1-n) Partnerships are developed to provide e Value Proposition (1-n)
Set of	Agreement(s)
Cardinality	0-n
Attributes	Inherited from Agreement

Table A.15: Agreement

Name of BM-Element	**Agreement**
Definition	An Agreement specifies the function and the terms and conditions of a partnership with an Actor
Element of	Partnership
Related to	An Agreement is always made *with* an Actor (1-n)
Cardinality	0-n
Attributes	Name {abc} Description {abc} Reasoning {Optimization and Economies of Scale, Reduction of Risk and Uncertainty, Acquisition of Resources} Strategic Importance {0-5} Degree of Competition {0-5} Degree of Integration {0-5} Sustainability {0-5}

Table A.16: Revenue Model

Name of BM-Element	**Revenue Model**
Definition	The Revenue Model describes the way a company makes money. It can be composed of one or several Revenue Stream and Pricing elements.
Part of	Financial Aspect
Related to	A Revenue Model is *built on* and depends of the firm's Value Proposition (1-n).
Set of	Revenue Stream and Pricing(s) (0-n)
Cardinality	1-n
Attributes	Inherited from Revenue Stream and Pricing

Table A.17: Revenue Stream and Pricing

Name of BM-Element	**Revenue Stream and Pricing**
Definition	The Revenue Stream and Pricing element describes an incoming money stream from the value offered by the company. Furthermore it defines what mechanism is used to determine the price of this value offered. The element is characterized by its attributes Stream Type and Pricing Method.
Element of	Revenue Model
Related to	A Revenue Stream and Pricing is for one or several Offerings (1-n) Every channel Link can have one or several Revenue Stream and pricing elements (1-n)
Cardinality	0-n
Attributes	Name {abc} Description {abc} Stream Type {Selling, Lending, Licensing, Transaction Cut, Advertising} Percentage {123} Pricing Method {Fixed, Differential, Market}

Table A.18: Cost Structure

Name of BM-Element	**Cost Structure**
Definition	The Cost element measures all monetary costs incurred by the company.
Part of	Financial Aspects
Inherits from	Account
Set of	Account(s) (0-n)
Cardinality	1-n
Attributes	Inherited from Account

Table A.19: Account

Name of BM-Element	**Account**
Definition	An Account is a registry of pecuniary transactions (expenditure) of a certain category.
Element of	Cost
Cardinality	1-n
Attributes	Name {abc} Description {abc} Sum {123} Percentage{123}