Techno economic evaluation of open access in Fiber to the Home networks: an operational analysis of churn

Nick Muylaert

Supervisors: Prof. dr. ir. Mario Pickavet, Prof. dr. ir. Sofie Verbrugge
Counsellor: Ir. Marlies Van der Wee

Master's dissertation submitted in order to obtain the academic degree of
Master of Science in Industrial Engineering and Operations Research

Department of Information Technology
Chairman: Prof. dr. ir. Daniël De Zutter
Faculty of Engineering and Architecture
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Overview

Techno-economic evaluation of open access in Fiber-to-the-Home networks: an operational analysis of churn

By Nick Muylaert

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Abstract

Competition within telecommunication markets has well known benefits such as an increased quality, a higher variety in offered services and a reduction in prices. Next to these benefits, competition allows for end users to switch providers when they are dissatisfied with their current service. This process of switching providers is known as churn. Even though churn has a positive effect on the market, it incurs additional processes and therefore additional costs as well. The goal of this work is to identify, model and optimize the costs related to churn. In order to do this, churn will be applied to an open access Fiber-to-the-Home scenario. The first step is the identification and the classification of the occurring churn. Following this cost identification, a model is implemented to study the churn specific costs. Two cases of churn will be examined: an end user churning service providers or an end user churning network providers. After the identification of the highest cost in the different churn procedures, optimizations are proposed and implemented. These optimizations are either based on equipment, processes or transactions.

Keywords: Churn, Fiber-to-the-Home, Techno-economic analysis

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***Abstract* – Within a multi-actor telecommunication market, competition will take on a dominant form. Competition will have a positive impact on the market dynamics as it allow for customers to transfer between providers. Within telecommunications, this transfer or switch between providers is known as churn. In order to facilitate the switch of an end user, additional processes are needed and these processes come at a cost. The first goal of this work is to identify and classify these costs related to the churn process. The identification of costs is based on a technical description of a Fiber-to-the-Home (FTTH) network and the offering of open access. By investigating the different network components, the different processes that are needed to facilitate the churn of an end user are identified. Once these processes are identified, the cost drivers for these procedures are determined and classified. The classification of the cost drivers is based on a tree structure and the main branches within this structure are equipment, process, and transaction related costs. Based on the determined cost drivers, a model is implemented to study the churn specific costs. Two cases of churn are examined: an end user churning service providers or an end user churning network providers. Results showed that the cost for churn in both scenarios is predominantly determined by transaction and process costs. Furthermore, the new provider is the actor with the highest assigned cost, closely followed by the old provider. This occurred due to both providers having high transaction costs. The final step of the analysis of the results contained the identification of the highest costs within each procedure. For these costs, optimizations are proposed and implemented. These optimizations are either equipment, process, or transaction-based. The outcome of the combined optimization showed that the cost for churn could be more than halved.**

Keywords- Churn, Fiber-to-the-Home, Techno-Economic analysis

I. INTRODUCTION AND MOTIVATION

Competition is a well-known part of telecommunication markets. Furthermore, the presence of competition allows dissatisfied customers to switch providers. This process of an end user switching providers is otherwise known as churn. Dissatisfaction with the current provider/service can occur for a number of reasons but the price and the quality of the service are the main determinants for churn [1], [2]. Even though the presence of churn has a positive effect on the market dynamics, churn will incur additional processes and costs. These costs can be differentiated in three components. First, there is the loss of customers and the corresponding loss of revenues. Second, costs will occur for the reacquisition of lost customers and the prevention of customers churning. Finally, the facilitation of the churn process itself will entail additional costs and these costs will be the focus of this work.

The impact of churn will be investigated in relation to a FTTH network. Deploying this new network entails a high initial investment and the size of this investment will be too high for a single telecom operator to bear. A solution to this problem is the introduction of cost sharing for the network infrastructure. This will result in different network operators each being active on a different network layer with separate core competencies. The physical infrastructure provider (PIP) will provide ducts, trenches, fibers, etc. The network provider (NP) will provide active equipment to ensure end-to-end connectivity and the service provider (SP) will offer services over the network. By splitting up the network and the resulting sharing of the network, open access based competition and collaboration will arise. Here, open access refers to the provisioning of lower layer functionalities to multiple actors on the layer above, and this in a non-discriminatory way [3].

The goal of this paper is the identification of the costs for churn (Part II), the modeling of the churn related costs (Part III), and the optimization of these costs (Part IV). Finally, Part V concludes this paper and gives directions for future research.

II. IDENTIFICACTION AND CLASSIFICATION OF CHURN RELATED COSTS OF OPEN ACCESS COSTS.

In order to investigate the impact of churn, the churn related costs must be identified and classified. The identification of the costs will form the basis for the modeling of the churn costs and classification of costs will aid in the investigation towards the nature of the churn costs. The classification of the churn related costs is based on a tree shaped cost breakdown structure. Three main branches are defined within this structure: equipment related costs, process related costs, and transaction costs.

Two main churn procedures are investigated. First, an end user can switch network providers. Within this procedure, competition between different network providers will occur. This means that multiple network providers exist on top of a single physical infrastructure provider (PIP) which offers fiber open access. This procedure can be further differentiated into two scenarios. Each scenario is based on a different topology, namely a point-to-point (P2P) or a point-to-multipoint (P2MP) topology. Here, a P2P topology refers to the situation where each end user has its own dedicated fiber. On the other hand, a

P2MP topology uses a shared fiber to serve multiple end users. The second churn procedure corresponds to an end user switching service providers. Here, competition arises between multiple service providers on top of a network provider which corresponds to the offering of bitstream open access. Within this document, the focus will lie on an end user switching between network providers.

The examination of the churn related cost is based on a qualitative description of the churn procedure. This procedure contains all necessary steps to successfully complete the churn of an end user. For each step, the occurring cost drivers are identified and classified. These cost drivers are then used to model the churn procedure. Each procedure can be summarized into a single flowchart. This visual representation of the churn process is based on the Business Process Model and Notation (BPMN). Here, BPMN provides businesses with the capability of understanding their internal business procedures in a graphical notation and allows the communication of these procedures in a standard manner [4]. Within Figure 1, an example of the complete churn procedure is given for an end user churning network providers over a P2P network topology.

III. MODELING OF THE OPEN ACCESS COST.

After the identification of the cost drivers within the churn procedures, a model is defined to perform an analysis on the impact of churn. The model calculates the cost for each churning procedure as shown in Figure 2. After specifying the churn procedure, the model requests the needed input values and supplies these values to the calculation module.

Here, the cost for each step within the procedure is calculated based on the specified cost functions. Once all costs are calculated, the model will classify the costs according to the defined cost breakdown structure and the responsible actors within the churn procedure.

The first result of the model considers the cost for an end user switching network providers and a P2P topology. The total cost for the churn of an end user is about € 395. This cost is mainly determined by process and transaction costs. Together, these costs take up about 85 % of the total churning cost. The transaction costs are slightly higher than the process costs and equal about 45% of the total cost. Furthermore, the transaction costs consist of the cost for an administrative subscription with the new network provider and an administrative termination with the old network provider. Both processes take up an equal share of the transaction costs. The process costs, on the other hand, are mainly determined by the operational processes, which equal about two thirds of the process costs. The operational process costs furthermore consist of the installation of a new ONT at the end user's premise, the logical connection and disconnection of an end user, and the repatching of the fiber at the central office. The remaining third of the process cost consists of the transportations to the end user and the central office

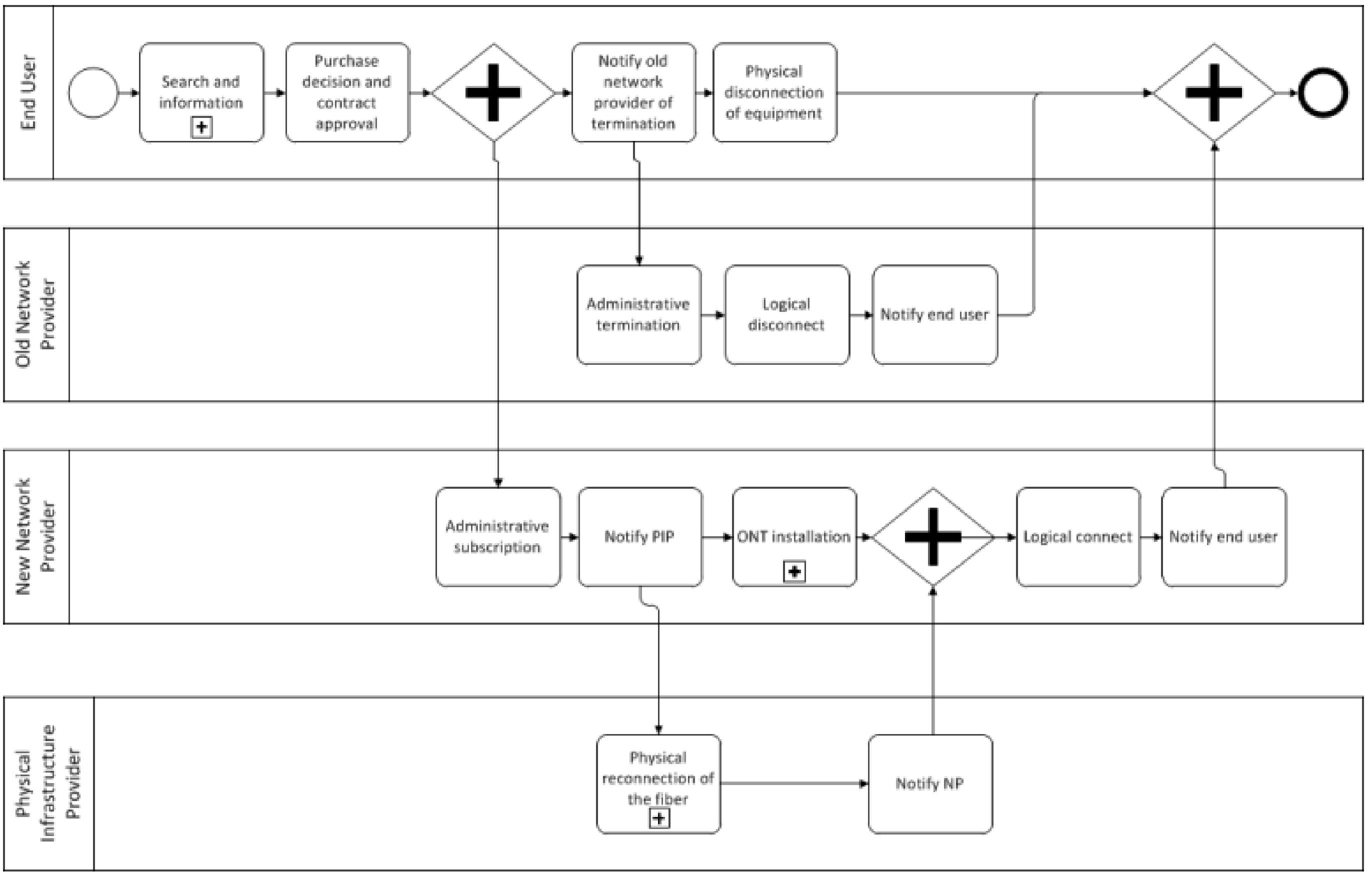

Figure 1: BPMN flowchart for an end user churning network providers and a P2P topology

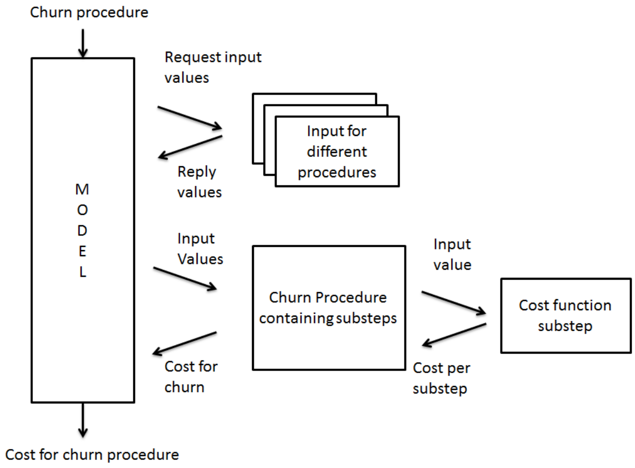

Figure 2: Schematic of the used model

Next to the churn of an end user within fiber open access over a P2P topology, the churn costs for a P2MP topology are investigated (Figure 3). The overall churn cost for a P2MP topology equals about € 385. Furthermore, the transaction costs are equal for both topologies. However, a distinction is noted for the process costs. The operational processes within a P2MP topology are cheaper as the cost for reconnecting a fiber is slightly lower. On the other hand, the cost for transport will be higher in case of a P2MP topology as the patching will occur at the street cabinet instead of in the central office.

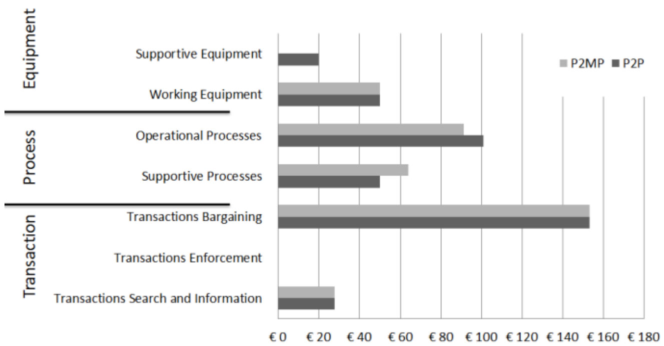

Figure 3: Comparison of the cost for an end user churning network providers.

An analysis of the cost assignment per actor shows that the majority of costs are assigned to the new network provider (NP_2) followed by the old network provider (NP_1) and the physical infrastructure provider (Figure 4). Here, the difference between the old and new network provider is defined by an end user churning from the old provider towards the new provider. Furthermore, only the costs related to the PIP differs between both topologies. The costs for the new provider are determined by transactions and processes, with the former being slightly higher than the latter. The main determining factor within the transaction costs is the presence of the administrative subscription of the end user. The process costs, on the other hand, are determined by the equal shares for the logical connection of the end user, the transportation, and the installation of the network equipment at the end user's premise.

The costs for the original network provider are mainly determined by the transaction costs which equal the administrative termination of the end user. Next to the transactions, a small amount of process costs is present. These costs correspond to the logical disconnection of the end user. The only difference in costs per actor is found for the PIP. Here, the process costs will be lower for a P2P topology since the required transportation is lower. However, equipment costs will be present.

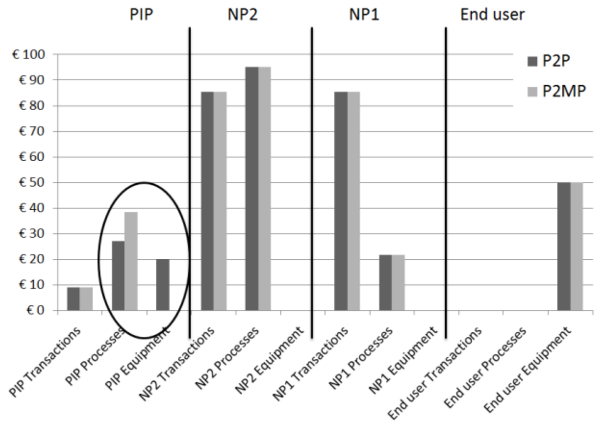

Figure 4: Comparison of the costs assigned to the different actors for an end user churning network providers.

Even though no process and transaction costs are shown for the end user, some costs will be present. By assigning an opportunity cost to the end user, these costs can be investigated. An opportunity cost is defined as the cost of the best possible alternative. Analysis through this opportunity cost showed that the transaction costs of an end user are relevant while the process costs remain negligible.

After the examination of the different cost assignments, a Pareto analysis was performed (Figure 5). This analysis is used to highlight the most important cost factors within each procedure. The highest identified costs within this analysis should then be the first focus when optimizing the churning costs. As a result, the costs best suited for optimization are the administrative subscription and termination, the equipment cost of the end user, and the transportation cost.

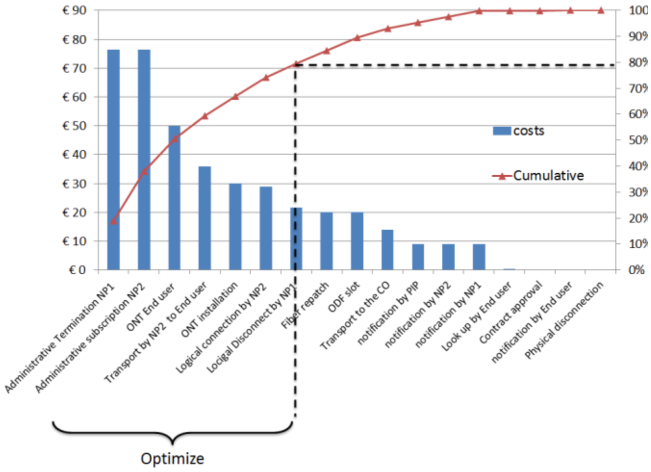

Figure 5: Pareto analysis for an end user churning network provider over a P2P topology

IV. OPTIMIZATION OF THE OPEN ACESS COSTS

After analyzing the different churn costs, multiple propositions are given to optimize the churning costs. The optimization of these costs focuses on the three distinctive cost categories as defined in the cost breakdown structure. First, equipment costs can be minimized through standardization. Second, process optimization can occur through the application of lean manufacturing. Here, lean manufacturing focuses on eliminating various kinds of non-value adding processes (waste). Finally, the optimization of transaction costs can be realized through the automating of different processes and the reduction of information asymmetry between the different providers.

The different optimizations are introduced step by step, and each optimization is built upon the previous one. The proposed optimizations are the use of standardized end user equipment, simplification of the administrative subscription and termination, pre-connectorized fibers in order to simplify the patching process, grouped fiber patching for multiple end users to reduce the needed transportation, the use of company–wide and interlinked databases, and the use of a neutral price comparison tool. By using these optimizations, the cost for an end user switching network providers is reduced by about 65%.

Figure 6 shows the effect of these optimizations on the cost assignments per actor. The used optimizations have a significant effect on all involved actors. For the network providers, both new and old, the transaction costs are reduced for about two thirds. Furthermore, the process costs for the new network provider is decrease by about 60% as there is no more need for the network provider to install new optical network terminal (ONT) at the end user's premise. Significant savings are also showed for the end user. Since the ONT is interoperable through standardization, no new equipment must be purchased.

Overall, the optimizations have the most impact on the transactions, supportive processes (transportation), and equipment, while the impact on the operational processes remains minimal.

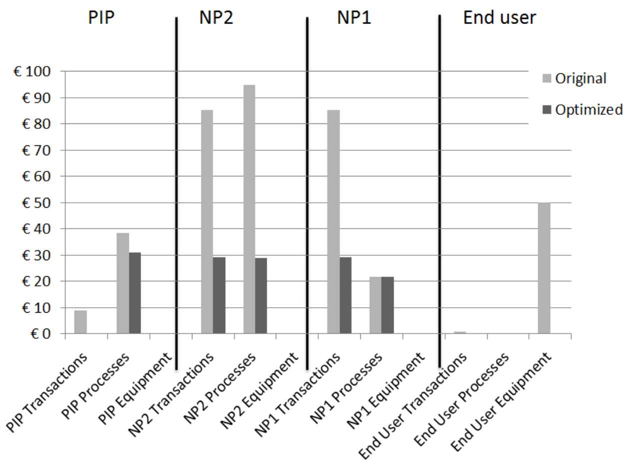

Figure 6: Comparison of the cost assignment per actor before and after optimization for an end user churning network providers

V. CONCLUSION

Competition allows dissatisfied customers to switch between providers. However, this switch between providers requires additional processes, each with its own cost. This work focused on the analysis of the churn related costs. An investigation of the size and nature of churn costs was made through modeling the different churn procedures in an open access setting. A distinction was made between an end user switching network and service providers. Within each procedure the distinctive cost drivers were identified and classified. Furthermore, the incurred costs for churn were optimized through minimizing the different aspects of the churn cost.

Within this document, the churn costs related to an end user churning network provider was examined. Analysis of the assignment per cost category showed that the majority of costs is attributed to transactions and processes. Furthermore, the new provider carried the majority of costs for churn. The application of the proposed optimization resulted in an overall cost savings of about 65%.

Next to the investigation of an end user churning network providers, the cost associated with an end user churning service providers was investigated. Within this scenario, a distinction was made between the service provider and the end user installing the end user's equipment. In case the service provider performs the installation of the equipment, the overall cost for churn is about € 420. For an end user installation, this cost is reduced to about € 360. Analysis of the cost assignments showed that the transaction costs and the process costs take up about 85% of the total cost for churn. The new service provider carried the majority of the costs and this cost was about equally distributed between processes and transactions. Furthermore, the main determinants of the churn costs for the new provider were the transaction costs. This is in contrast to the cost associated with the network provider, where the process costs take up a dominant share. Application of the proposed optimizations resulted in a cost saving of about 55% in case of churn over bitstream open access.

Future research for improving this work contains increasing the diversity in the offered services. For example, a cost difference will be expected for churn between over-the-top and regular services. Furthermore, the addition of wavelength open access can be considered as an alternative for fiber open access and will impact the costs for churn. Finally, in order to reduce impact on the end user, one can investigate the scenario where the new provider is responsible for all administrative processes, including the termination of the contract with the old provider.

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REFERENCES

[1] MATTISON, Rob. *The telco churn management handbook*. Lulu. com, 2006

[2] AHN, Jae-Hyeon; HAN, Sang-Pil; LEE, Yung-Seop. Customer churn analysis: Churn determinants and mediation effects of partial defection in the Korean mobile telecommunications service industry. *Telecommunications Policy*, 2006, 30.10: 552-568.

[3] OASE, "Value network evaluation". Project deliverable (D6.3). Available: http://www.ict-oase.eu/.

[4] http://www.bpmn.org/

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Abbreviations

CO:	Central Office
EAS:	Ethernet Aggregation Switch
E-NNI:	External Network- Network Interface
FTTB:	Fiber to the Building
FTTC:	Fiber to the Curb/Cabinet
FTTH:	Fiber to the Home
FTTN:	Fiber to the Node
FTTX:	Fiber to the X
FTTP:	Fiber to the Premise
GPON:	Gigabit-capable Passive Optical Network
IPTV:	Internet Protocol Television
NP:	Network Provider
NP_1:	Old Network Provider
NP_2:	Alternative or New Network Provider
ODF:	Optical Distribution Frame
OLT:	Optical Line Terminal
ONT:	Optical Network Terminal
OVC:	Operator Virtual Circuit
P2MP:	Point-to-multipoint
P2P:	Point-to-point
PIP:	Physical Infrastructure Provider
POI:	Point of Interconnect
RGW:	Residential Gateway
SC:	Street cabinet
SP:	Service Provider
SP_1:	Old Service Provider
SP_2:	Alternative or New Service Provider
TDM:	Time Division Multiplexing
UNI:	User Network Interface
VoIP:	Voice-over-Internet Protocol
WDM:	Wavelength Division Multiplexing

Chapter 1 Introduction

In a world where the everlasting drive for perfection and the best never stops, consumers will rely more and more on reliable and high quality telecommunications networks and services. The European commission will aspire to this goal through its Digital Agenda [1]. One way to achieve this goal is to increase and guarantee competition. Competition occurs when at least two actors offer similar services. Whether the goal of the actors is the highest revenue, largest customer base or even the best service, competitors will strive to be the best. Competition will therefore force competitors to raise quality and reduce their prices.

In order to raise quality, companies will innovate and create new products and services. This is also the case within the telecommunication sector. Here, an increased demand for higher bandwidths and the creation of new services results in the innovation of a new fixed fiber access network. Next to the increased quality, competition will extend the number of available offers and increase the variety amongst these offers. With the increase in variety also comes an increase in customer choice and choice will mark change. Competition will only support economic growth though. This occurs on the one hand because competition will keep the prices down and on the other hand through an increase in productivity and efficiency.

Competitive markets are therefore seen as beneficial for the consumer. The increased quality, reduced prices, and a greater variety are all benefits of competition. Through the presence of competition, consumers are allowed to change network and/or service provider when they are not satisfied with their current offer. The process of changing provider within the telecommunications sector is also known as churn. Even though churn has a positive influence on the market dynamics, additional processes will be incurred to accomplish the switch of providers. Furthermore, these additional processes will entail corresponding costs. These costs will relate to the equipment, operational processes and transactions that are needed to facilitate these processes. Furthermore, the investigation of churn will be applied to new access networks such as Fiber-to-the-Home (FTTH) networks.

This work will focus on the different parts of the churn related costs and has the following research question: **How can the cost for churn in an open access FTTH network be identified, modeled, and optimized?**

Within Chapter 2, an investigation is made of the available literature. This investigation focuses on the existing literature regarding the key terms of the research question. The first keyword is the process of churn. To start the churn investigation, a definition of churn is given, followed by a description of the different types of churn. Furthermore, the occurrence of churn is investigated. The final section of the literature study on churn covers the costs for churn as well as regulatory decisions of governments regarding churn costs. The second part of the literature study covers the different aspects of open access in a Fiber-to-the-Home

(FTTH) network. Here, the different network layers and an open access business model within a FTTH network are conceptually introduced.

Chapter 3 considers the technological realization of open access on a FTTH network. Through studying the realization of this new access network, the network components that will be affected during churn are identified. The first part of this chapter will give a description of the needed components of a FTTH network. After the investigation of the different components, an examination will be performed on how open access can be offered and this for opening up the network at different network layers. By opening up the network at the level of the physical infrastructure provider (PIP), competition will arise between different network providers and consumers will be able to churn network providers. One possible way for offering open access at this level is through fiber open access. The network can also be opened at the network provider level, allowing for competition between different service providers using bitstream open access. A benefit of bitstream open access is the fact that this type of open access can be offered independent of the chosen network topology.

After the investigation of how open access can be offered, chapter 4 will outline the process of churn through a detailed description and the use of flowcharts. The flowcharts of the churn processes are based on BPMN, where BPMN stands for the Business Process Model and Notation. Within the description, the different churn processes are broken down in smaller parts and for each part a cost driver is designated. The costs are then classified by a cost breakdown structure.

Within chapter 5, a model for churn is defined. Within this model, the cost for churn is investigated for bitstream and fiber open access. The scenario of bitstream open access will be further differentiated into an end user installation and a provider installation. In the case op fiber open access, the distinction will be made between a P2P and a P2MP topology. Next, the results of the model are discussed and the focus lies on two aspects. The first aspect focuses on the cost for churn of one single end user. Here, the different network scenarios are taken into account and the most suitable costs are identified for optimization. The second part of chapter 5 focuses on a market analysis.

Next, the optimization possibilities identified in chapter 5 are the subject of chapter 6. The proposed optimizations will focus on the different aspects of the churn process, i.e. equipment, processes and transactions. Finally, chapter 7 will conclude this work and give an indication for future research.

Chapter 2 Literature study

Within this chapter, the existing literature regarding this work will be investigated. Furthermore, the examination of the existing literature can be split up into two distinctive parts. The first part will focus on the different aspects of churn, while the second part will focus on open access. The start of the churn section consists of the definition of churn. Next, the different types of churn and their drivers are investigated. Alongside the examination of the different types of churn, the origin of churn within a market is investigated, i.e. why does churn occur in a market. Afterwards, the different costs related to the churn of an end user are investigated as well as regulatory actions undertaken by governments. The second part of this chapter focuses on the different aspects of open access in a new access network. The first aspect is the investigation on the possibilities of realizing this new access network. Furthermore, the different network layers and network actors that will occur in this new access network are introduced. Finally, an investigation is made on how open access can be offered.

2.1 Literature study: The definition and impact of churn

Competition within markets has well known benefits such as an increased quality, variety in offers and a decrease in prices. Next to these benefits, competition allows end users to switch providers when they are dissatisfied with their current service. This process of an end user switching between providers is otherwise known as churn. Even though churn has a positive effect on the market, it incurs additional processes and therefore additional costs as well. Within this section, the different aspects of churn will be investigated.

2.1.1 The definition and significance of churn

Within service provisioning, churn is a widely used term. But what is churn actually? Customer churn in the broadest sense can be seen as an individual moving out of a collective group to join another one and is also referred to as customer attrition, customer turnover or customer defection [2]. The term churn can be used in many contexts, but is mostly applied to businesses or markets having a contractual customer base a seen within the telecommunications sector. As a result, churn refers to the migration of customers to a competitor resulting in a loss of revenue for the original company. Closely related to churn is the churn rate. The churn rate corresponds to the percentage of contracted customers who end their contract or subscription during a given time period. Furthermore, it can be seen as a measure of the customer lifetime. Many subscribers frequently churn from one provider to another in search for better prices and/or services, or for other benefits of signing up with a new provider [3]. These additional benefits are related to promotions that companies will use to make customers churn. Examples of these benefits are a reduced price during the first months of the subscription or cheap hardware products such as televisions, phones, tablets, etc. when starting up a new subscription.

Churn therefore is an important factor within subscriber-based service models. The offered services can be the ones from a bank, an insurance company, or a telecommunications company offering a telephone, internet, or video service. Churn can also be seen as an indicator of customer dissatisfaction, the availability of cheaper and/or better offers within the market, or the success of the competition.

Customer churn takes up a special place within the telecommunication sector. This is especially true because of the low barriers for churning to a competing service provider. Examples of these low barriers is the preservation of your mobile phone number when you switch between different providers, short outage time, little to no administrative procedures for the customer, low costs for the end customer, etc. Furthermore, values for churn range from 1% to 4% per month, which corresponds to an annual churn rate ranging from 20% to 40 % for most of the global mobile telecom [4]. More specific [5] reports that annual wireless telecom churn rates vary from 25% in Europe over 37% in the United States to 48% in Asia. Within [6] and [7] , it is listed that one in seven or about 15% of subscribers worldwide abandoned their internet service provider every year. On the other hand, [8] states that over a time period of 2 years within the European Union, 22% of Internet service users churned, and 18% for fixed-line telephone services.

2.1.2 The different types of churn based on personal determinants

Companies can make a distinction between two types of churn. These types are involuntary churn and voluntary churn [2]. Voluntary churn can be further divided into incidental and deliberate churn. The first type of churn, involuntary churn, corresponds to forced churn, meaning that the customer is not the initiating party of the churn. Instead, it is the provider of the service that decides that a subscription should be terminated. Examples for this type of churn include the termination of the service or non-payment. The first example corresponds to a provider ending the offering of a specific service, as the service might be outdated or not profitable anymore due to costs heavily outweighing revenues. In this case all subscriptions will be terminated and customers are forced to churn if they want to keep receiving a similar service. The second example, non-payment is applicable to one single customer and not to the entire customer base. Here, a customer is late with the payment of their bill or does not pay at all. In this case, the provider will decide, usually after a few months of non-payment in a row, to terminate the subscription of a single customer. It is then up to the customer to decide whether or not to subscribe to another provider. In case the customer cannot pay the bills, it is most likely that the customer chooses not to take the service any more.

Voluntary churn can be differentiated into incidental and deliberate churn. The first type of voluntary churn, incidental churn, occurs not because the customer planned the switch between companies but because the customer has made some life-changing decisions. By making such a decision, the termination of the service will occur as a side effect and can be seen as a natural part of doing business. An example of involuntary churn can be seen for a customer emigrating to another part of the country or the world where the service of the original provider is not available. This will result in the customer churning to an available alternative service if the customer wants to keep receiving the service.

The second type of voluntary churn is deliberate churn. This type of churn is not forced by a provider, but willingly chosen by a customer, as the customer will initiate the termination of the contract. Determinants of deliberate customer churn are customer dissatisfaction, social aspects, etc. [2], [4]. The most well-known reason for customer dissatisfaction is the price of the service. This price-driven churn is often the most mentioned reason for churn as customers are sensitive to prices. The second most common reason for deliberate churn is the quality of the service. People subscribe to a service for the quality and if, for example, a customer discovers a similar service with the same price but with a higher quality, the customer will perceive it to be advantageous to churn. However, the quality of the service itself might not be the only determining factor. The perceived quality of indirectly related services such as a customer help desk, or billing method can also prove a valid reason for customers to churn.

Next to the obvious reasons such as prices and quality, some social factors might trigger churn. These social factors include indirect pressure of family and friends and the image a company has. First, family and friends have a strong influence on the decision people make [9]. Hence, it is logical that the people surrounding a customer will have an influence on the churn-related decisions a customer makes. This effect is also related to network effects/externalities [10]. Here, the network effect is defined as the effect that one user of a service has on the value of the service to other people. A positive effect is seen if the value increases with increasing numbers. An Example of this effect is seen for the telephone or social networks. If you are the only person with a telephone, it will not be of much use. On the other hand, the more people own a telephone, the higher the value becomes. Another factor is branding or brand management by companies. When the projected image of a brand does not coincide with the ideals of a customer, the customer will be tempted to churn. Even though social factors might not be the main reason for churn, they can have a serious impact on the decisions to churn.

When companies decide to tackle the reasons behind churn, the focus will lie on deliberate churn and not on involuntary or incidental churn. The reasoning behind this is that deliberate churn occurs due to factors that can be influenced by the provider itself. The provider can decrease its prices, increase quality, or provide a better customer service. Furthermore, deliberate churn is the most common type of churn. Therefore, the modeling of churn in this work will focus on this type of churn. Meaning that when a customer terminates his contract, he will switch to another provider

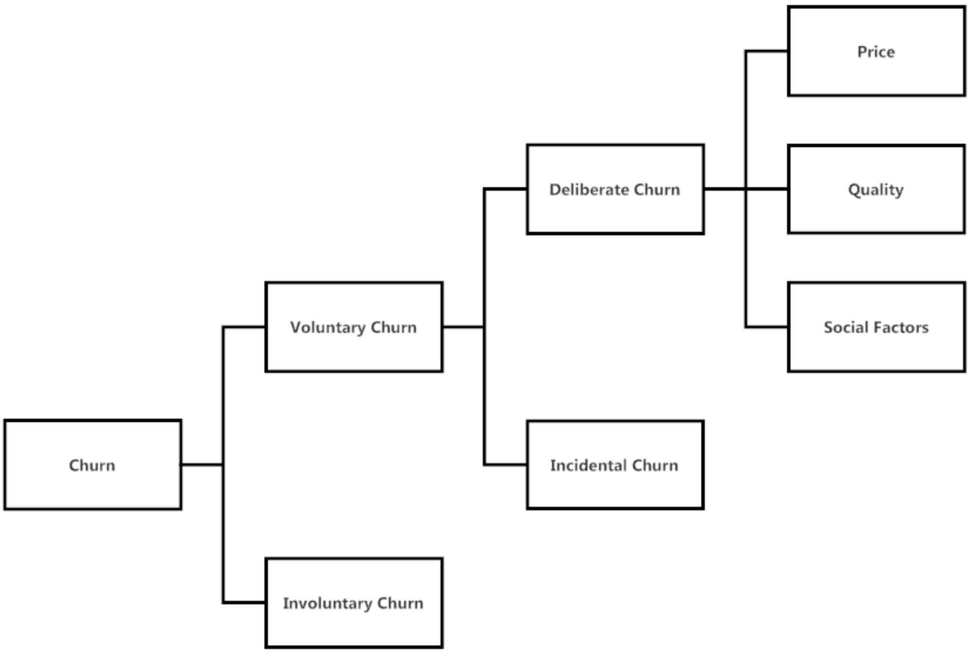

Figure 1: The different types of churn

2.1.3 The origin and occurrence of churn within a market

Within telecommunication, companies will eventually be forced to deal with a serious of churn. This happens because churn is inevitable for a number of reasons. In the previous section, the personal drivers on why customers churn were listed next to the different types of churn. Within this section, an examination is made of why churn within a market is possible. The first cited reason for churn within [2] is technological innovation. As technology keeps changing rapidly through the invention of newer, better, and less expensive alternatives, customers will have an increased choice in the product they want to use. As a result of this fast-paced innovative process, new technologies within the telecommunications sector will generate their own decay in a very short amount of time. Naturally, when the current technology that a company uses is made obsolete by a new technology, an extremely high rate of churn can be seen. Furthermore, high-technology industries, such as the telecommunications sector, have a built-in product obsolescence cycle; it is guaranteed that churn will be a reoccurring phenomenon.

The second reason cited is the behavior of consumers themselves. Through the fast generation of new technologies, consumers that quickly fall in love with a certain technology will easily trade it for a newer and better technology.

The third reason cited is local governments and regulators. When a company is holding a monopoly position in a market, not much competition is available. This competitive deficiency will be addressed by the regulators.

Even though the previous reasons all result in churn, the major and real reason for churn is competition. It is the competition that will generate the drive towards the development of new networks and technologies, new offerings, increased quality and the reduction of prices. In a saturated market, i.e. a market where a product has become almost fully distributed amongst consumers, companies that try to increase their market share will not look for new customers that have to adopt a similar product, but try to acquire customers from their competitors. As competition increases between companies, customer churn becomes an issue to deal with by the telecommunication providers. Because of competition, companies cannot fully prevent churn as one cannot prevent its competitors from reducing prices and advertising their services. Within [2] it is stated that, if churn was preventable, or if churn conditions could be experienced without the loss of revenue, then churn would not be perceived as that big of a problem by providers. Furthermore, it is stated that no matter what a company tries, when churn conditions are right, then competitors will try to take your customers away, either through price reductions, increased service quality, etc.

2.1.4 The significant of churn over time

In order to investigate influence of churn over time, either through the presence of churn or its significance, one must first introduce the product life cycle. The product life cycle, first introduced within [11], shows that every product or service undergoes four stages in its lifespan (Figure 2). The duration of each stage can vary from a few weeks to decades in time. The four stages are introduction, growth, maturity, and decline. Within the first phase, introduction, a successful product development is concluded with the introduction of a product or service into a market. As the product is still new, little to no competition will be present. During the second phase, the sales of the product increases rapidly and competitors will introduce their own product to the market. During the third phase, maturity, the competition will become fierce and the product or service will be widely available. In the final phase, decline, most competitors will be removed from the market and eventually the offering of the product or service will come to an end.

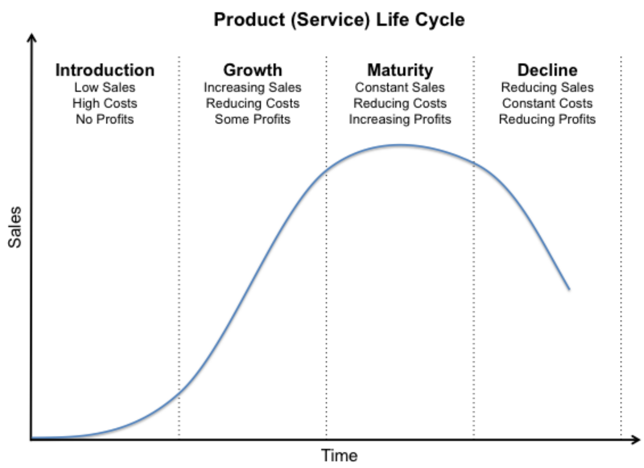

Figure 2: Product life cycle [12]

Usually, the first time a company will notice churn is when the rapid expansion of the market begins to slow down. At this point in the time, the market begins to saturate as the current prices and quality will stagnate. While the initial shock of churn occurs during the end of the growth phase, the day-to-day “steady state” churn conditions that the company must deal with will occur only when the growth is over and the maturity phase begins. As within the maturity phase a steady state is available, the amount of churn will also stagnate and become more predictable. Furthermore, in the early phases of the lifecycle, the amount of churn will be low and costly. However, as the amount of churn will increase during the growth and maturity phase, the total cost for churn will also increase. This shows the significance of optimizing the churn procedure by providers, as will be studied in chapter 6.

The different lifecycle phases are introduced as companies will experience churn differently during the different phases. During the first three phases, sales will increase and costs will be reduced resulting in an increase of the profits. When a consumer decides to churn, it will mean a loss in revenue for a company and thus less profit. Companies will therefore see churn within this phase as being negative. This is in contrast to churn during the last phase, the decline phase. Within this phase, sales are reduced as customers move on to a new service. However, as costs remain constant or even increase due to aged equipment, etc. profits will be reduced or even losses will be made. As a result, any churning customer will reduce the costs for the company while having a minimal impact on profit losses and companies experience this type of churn as a good churn. Within this phase, some companies might urge customers to churn as they try to dump the less profitable customers onto the competition. This way they only keep the most profitable customers in order to maximize profits.

Because of the saturated market during the maturity phase, the competition will increase as new customers are acquired through customer migration. This happens as a saturated market means that there are very little numbers of remaining adopters [13]. As a result, an operator has to shift its focus from an acquisition strategy onto reducing churn rates and keeping their own subscribers away from the competition. This occurs because the cost of acquisition is five times higher than the cost for retention [5].

Next to the churn during the maturity phase, the introduction of a new entrant in a saturated market can have a huge impact on the amount of churn. When a new entrant arrives in a saturated market, the status quo of market shares will be disrupted. Telecom incumbents are then faced with an increase in customer churn rates, resulting in eroding market shares and revenues. In this case, a telecom incumbent refers to a company that held a former monopoly but still has a dominant market share [14].

2.1.5 The different costs related to the churn of a customer

Churn is an inescapable part of competition within a market. However, churn is also proven to be expensive. This results from the fact that each consequence of churn carries a price tag. The first and directly visible aspect is the loss of customers and therefore the loss of revenue. When a customer terminates his subscription and moves to a competitor, no more revenues will be gathered. The cumulative loss of a larger number of churning customers can therefore create a large deficit in a company's balance sheet as extra costs are introduced to facilitate the churn and the revenues are decreased. Indirectly related to this is the generation of lower revenues from the existing offers. When churn starts to occur, companies will react by dropping the price of their products. This is done to convince customers not to leave as the own product is still competitively priced. However, the reduction in selling price means a reduction in company's revenue.

A second cost component is the cost for reacquisition of lost customers and the costs for customer retention. The latter corresponds to companies putting effort in preventing customers from leaving while the former corresponds to an effort in convincing customers to return to their old provider. Even though companies will try to prevent churn, it is inevitable that customers will be lost to the competition. However these customers can be convinced to return to the original company and hence can be reacquired by the company. For gaining a new customer, a company must spent five to ten times the amount needed to retain a customer and the cost of acquisition of a new service subscriber is estimated to be between about $ 300 (€ 250) and $ 600 (€ 500) [3]. As a result, predictive models and customer relationship management will gain importance as companies start to realize that their existing customer base is their most valuable asset [5], [15].

A third aspect is the cost for the churn process itself. When customers switch between companies, costs are imposed on the 'losing' company. These costs correspond to processes that will need to be performed and for each single process there will be a corresponding cost. Examples of this process include the administrative termination and disconnection of customers. Values for these churning costs range from about €150 [16] to € 500 in [17]. In most cases, these churn costs are never recovered even though they could be built into initial contract agreements as a severance clause. Furthermore, a new customer can churn away before the company can fully recoup its acquisition cost. Within this work, the focus lies on the impact of the cost related to the churn process.

2.1.6 The impact of regulators on churn and churning costs

As the churn of a customer results in additional costs and a loss in revenue, companies will try to recover these costs through termination fees. As a result, termination fees are common in service industries such as the telecommunication sector and correspond to fees a customer has to pay in order to break the terms of agreement or long-term subscriptions. However, these termination fees can be seen as anti-competitive because they form a barrier and decrease churn.

In order to counteract this policy, the Belgian government introduced a new telecommunications law. This law, dated on the first of October 2012, states that an operator cannot claim any compensation cost when a contract is terminated after six months, independent of the contract type (fixed duration contracts versus indefinite duration contracts) [18]. Furthermore, the government states that the cancellation of a contract must be made easier and can be done by the consumer at any given point in time. Alongside, the operator must terminate this contract as soon as possible.

As a consequence of this new law, Belgian operators have adjusted their contracts, making all contracts for an indefinite duration and claiming no contract termination fees [18] [19]. This furthermore results in all termination costs falling onto the operator, which drives them to minimize these costs. Within this work, a contract termination fee will not be taken into account when investigating the impact of churn.

Outside Belgium, the European Union will also try to increase competition through directives or regulations. Here, a directive refers to a legal act of the European Union, which requires its member states to achieve a result without dictating the means to arrive at this result. An example of such a directive is given by [20] where article 30 gives directions towards the facilitation of changing providers. A first inclusion is the fact that contracts do not mandate an initial commitment period that exceeds 24 months. Second, member states shall ensure that conditions and procedures for contract termination do not act as a disincentive against changing service providers.

Next to directives, the European Union introduced a regulatory framework to aid with the achievement of its digital agenda [21]. This framework is a series of rules that apply to the European Union member states to encourage competition, improve the market, and guarantee consumer rights. An overview on the progress of different countries on implementing this framework [22] shows that most implementations are towards the termination of contracts in order to make churning easier. For example, within Denmark, contractual obligations cannot have a binding period for more than six months. Within Spain, a telecommunications law grants the consumers the right to request for contract termination at any time and the right to withdraw from the contract without penalty upon notice that the provider changes the contract. Within the Netherlands, a law imposes that a consumer has the right to terminate a contract at any time with a one-month notice period.

2.2 Literature study: Open access within new access networks

In order to investigate the impact of churn, churn will be examined in relation to a new access network. The next sections will describe the possible realization of this access network alongside the different business models and responsible actors within this new access network.

2.2.1 Next generation access networks

With improved telecommunication services, the demand for higher bandwidths gives rise to the need for a new access network. The current copper and cable infrastructure can be replaced by fiber optics which use light pulses to transmit signals, resulting in different Fiber to the X (FTTX) scenarios [23] [24]. Within each different scenario, the optical fibers are brought closer to the homes of end users (Figure 3) and range from Fiber to the Curb (FTTC) to Fiber to the Home (FTTH).

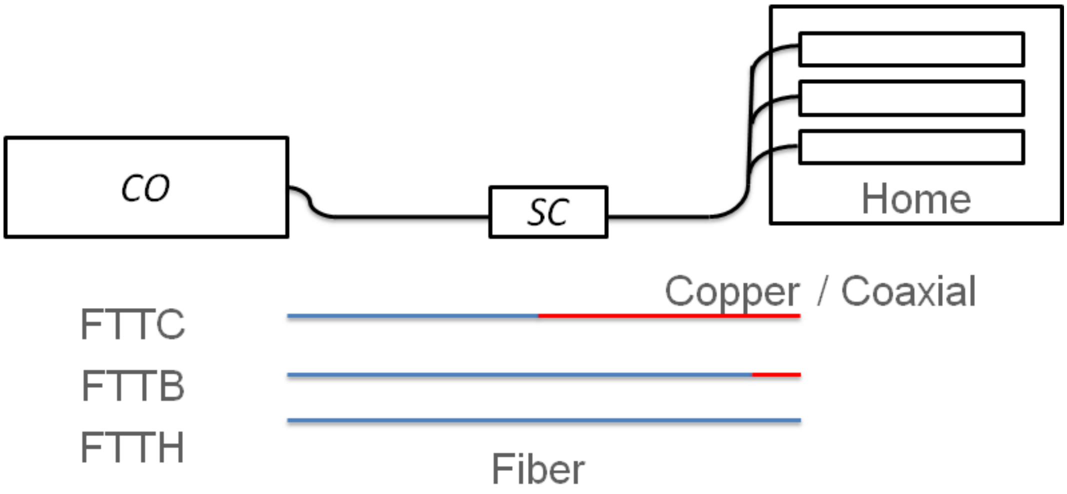

Figure 3: Representation of the different upgrades for a fiber network

A first scenario is Fiber to the Curb/Cabinet (FTTC) also referenced to as Fiber to the Node (FTTN). In this scenario, optical fibers run from the central office (CO) to the different street cabinets near the end users. From this point onward, a traditional copper or coaxial loop will ensure the connection towards the different end users. Within this scenario, higher bandwidths will be achieved compared to the original copper or coax networks because the lengths of the copper or coaxial based segments are shorter. However, the maximal achievable bandwidth of this network will depend on the length of these segments, as the bandwidth will decline the longer the copper line from the street cabinet to the end user is. Since this scenario uses two different mediums to transmit the signals, this scenario can be classified as a hybrid technology.

The second possibility of realizing a new access network is Fiber to the Building (FTTB) and is only applicable for multi dwelling units such as apartment buildings. Within this scenario, the optical fiber runs from the CO to a point near the end users premises, typically the basement of the apartment building. The in-house wiring from this point onwards is still copper-based and therefore this scenario is also classified as a hybrid technology.

The third scenario is Fiber to the Home (FTTH) or Fiber to the Premises (FTTP). Within this scenario, the fiber runs all the way from the CO to the active termination unit of the end user and can be seen as an upgrade of both FTTC and FTTB. As there is no copper or coaxial based segment within this loop, one can truly speak of a new access network. The main difference with the current networks is the fact that far greater bandwidths are provided and greater distances can be covered without signal losses.

2.2.2 Network layers and responsible actors within a network

Fiber optic networks are the most future-proof as they offer the highest bandwidth over long distances. However, models found in [25] [26] [27] state that the deployment of a new optical network requires high investments. These investments are mostly needed for the construction work related to civil works and the deployment of the passive infrastructure. These costs can sum up to 70% of the total cost related to deployment of a new network [28].

A solution for this high investment cost is the sharing of the cost for network infrastructure between different players so that not every player has to make these costs. This reduces the entry barrier on the network or service level, eliminates the duplication of the large investment for physical infrastructure and civil works, and spreads the risk over different actors. Existing business models distinguish three conceptual network layers: the physical infrastructure layer, the network layer, and the service layer. Typically, one type of provider can be assigned to each of the three layers. The respective providers are: the physical infrastructure provider (PIP), the network provider (NP), and the service provider (SP). Within [29] the providers on the different layers are defined as followed: the PIP will be responsible for obtaining right of way, digging trenches, and installing ducts and fibers. The NP will deploy and operate the active equipment needed to ensure end-to-end connectivity. Finally, the SP will use this connectivity to offer services such as Internet Protocol Television (IPTV) or Voice over IP (VoIP). The separation into different providers is made because of the different technologic and economic nature of the network layers. The physical infrastructure for example, has high capital expenditures. As a result, the formation of a monopoly may come naturally and therefore the physical infrastructure layer is sensitive to regulation. On the other hand, the higher network layers with the active equipment require more operational expenditures and technical competencies.

Figure 4 shows the possible business models for a FTTH network, ranging from one vertically integrated operator to full separation. The higher on the layers that connectivity is offered, the more sharing of the network occurs, which results in a decrease in isolation and freedom. The decrease in freedom, and therefore the decreased flexibility, is the result of the increased incorporation of network functionalities. As a result, operators will have to comply with the methods of other network operators, which will limit their own technology and operational choices. Network isolation, on the other hand, is achieved when a defective piece of network equipment cannot disrupt the service of other providers. As an example, in case of network providers, each network provider will have access to its own dark fibers. Hereby, the network provider becomes isolated of other providers.

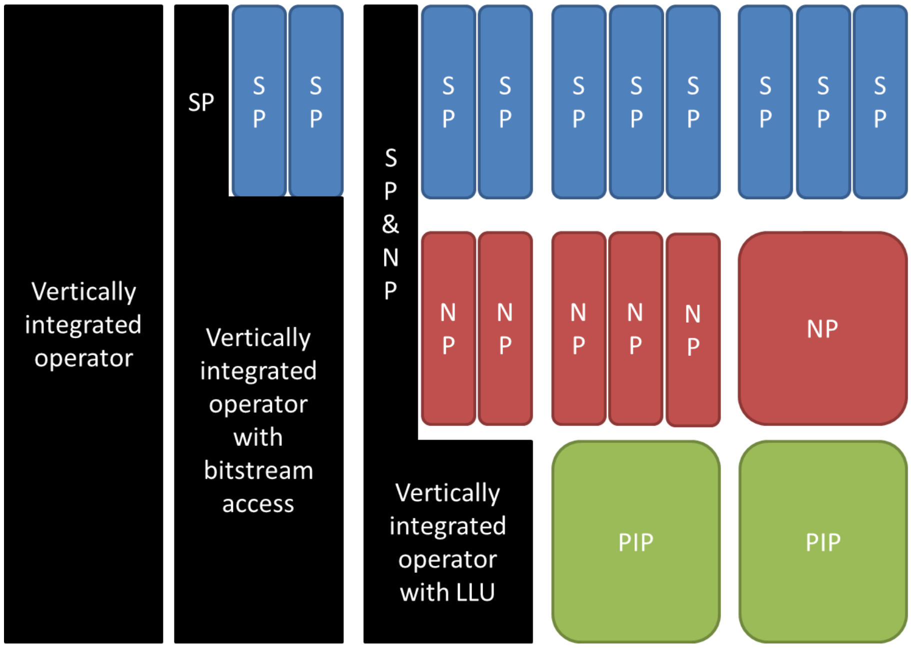

Figure 4: Business models in telecom, figure adapted from [16] and [30]

Furthermore, the business models from Figure 4 can be split in two categories [16]. The first category (on the left of Figure 4) applies to unbundling. Here, unbundling refers to a single actor being active on a particular network layer and on the network layer above, while still allowing other actors on top of its own network. Here, the vertically integrated operator was forced by a regulator or chose to open up the value chain. The second category (on the right of Figure 4) applies to open access. Here, open access refers to the provisioning of a network layer to the actors on the layer above without making a distinction between these actors. The difference between both categories lies with the fact that in the case of open access, an actor of a specific network layer does not offer services at a higher network layer.

The different scenarios from Figure 4 each have their advantages and disadvantages [31]. Vertical integration (left side of Figure 4) has the benefit of direct and full end-to-end control. However, as a disadvantage, the entire infrastructure needs to be duplicated in order to allow competition. Full separation on the other end of the spectrum (right side of Figure 4) has the benefit of clearly defined roles within the network with no overlapping competencies. However, by separating all roles, additional costs will arise between companies to ensure a correct functioning. Within the scenario of full separation, and therefore within open access, mostly one PIP is present. The main reason lies with the fact that the high investment cost of the physical infrastructure results in a natural monopoly for the PIP within a single geographical area. This high investment cost is the main reason why there is no valid argumentation for infrastructure-based competition [16], [32].

By fully separating the network as shown on the right side of Figure 4, two types of interactions may occur (Figure 5). The first interaction that can be distinguished is competition. Competition occurs between players on the same network layer and is a result of different activities that have the same value-added step or by the existence of some form of overlapping core competencies. The second type of interaction is that of vertical cooperation and relates to different complementary value-adding steps at different network layers.

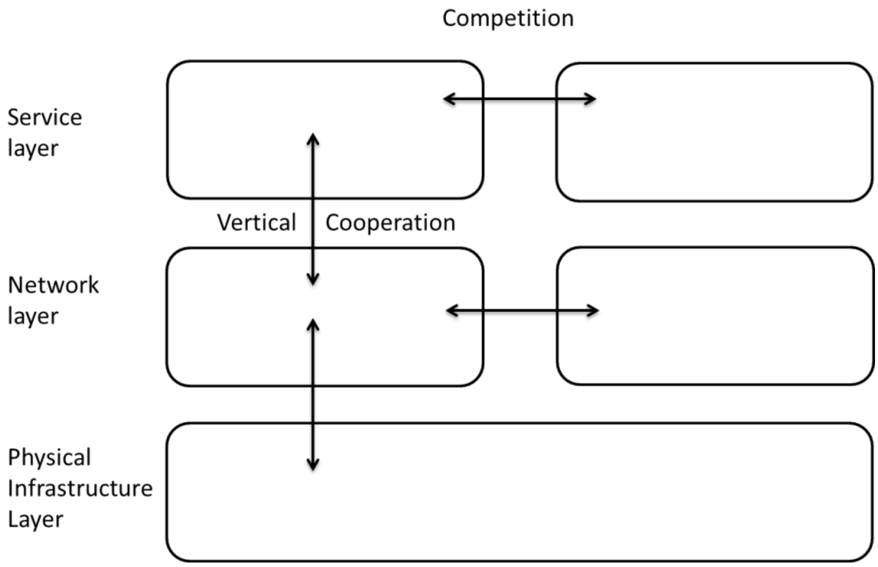

Figure 5: Possible interactions between different network layers, adapted from [32]

Combining the information from Figure 4 and Figure 5, two interfaces can be distinguished for vertical cooperation. The first interface is the vertical cooperation between the SP and the NP where the NP will provide end-to-end connectivity for multiple SPs. The second interface is the vertical cooperation between the NP and the PIP. Here the PIP leases out dark fibers, while the NP will operate a network over this infrastructure.

2.2.3 Open access within an access network.

Open access will make the new business models for FTTH networks as discussed above a viable economical solution where not all actors have to make huge investments [33]. Open access will therefore allow the presence of multiple network and service providers. This will result in increased competition and a price reduction for the corresponding services, which in turn makes the new access network more attractive to new end users [34]. Furthermore, offering open access can lead to a significant increase in network utilization. The increase in network utilization is a result of the sharing of a single network by multiple actors.

However, not every cost is reduced because with open access, new technological requirements may occur such as additional functionalities or network components in order to allow competition. Furthermore, as seen in Figure 5, cooperation costs between the different involved parties will occur, [16]. In order to provide open access the network must be opened at a specific network layer which allows for competition on the higher layers. The network can be opened at different levels but only two levels will be considered. With the first level, the network is opened at the PIP level meaning that there will be NP competition.

Two options are available at this level. Either the network is opened at the fiber layer or it is opened at the wavelength layer.

The first option, fiber open access, relates to different parallel fibers being available whereas each fiber provides a dedicated link to each end user. The second option, wavelength open access relates to every NP having one or more dedicated wavelengths to reach the end users. Alternatively, seen from a different angle, this means that the end user can select a specific NP by selecting one or more dedicated wavelengths [35].

For the second option, the network is opened up at the NP level, which allows for SP competition. Here, bitstream open access is available and this type of open access can be offered at different layers of the OSI-model. A benefit of this technique includes the fact that bitstream open access can be offered independent of the used topology on the network layer [36]. The different types of open access will be further investigated in Chapter 3.

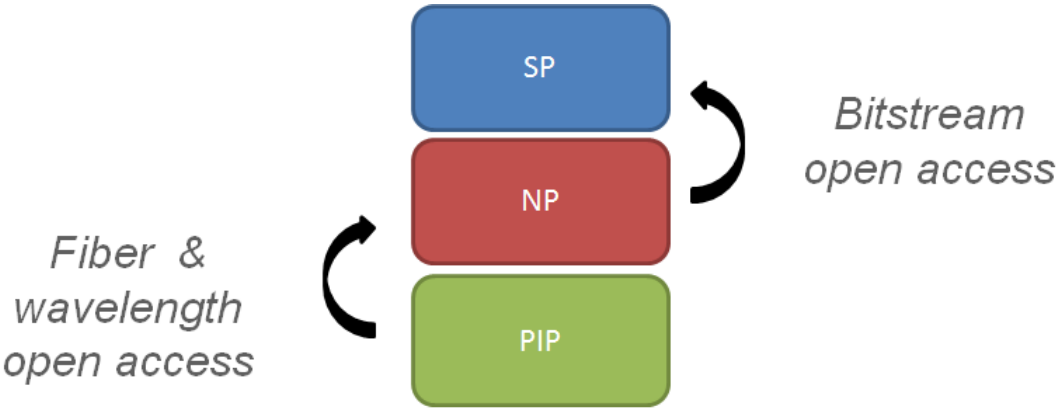

Figure 6: Available types of open access

Because of the high initial infrastructure investments, experts state that open access is the most suitable for establishing market driven next generation access networks [37]. Furthermore, in order to increase the market dynamics, regulators turn towards the "ladder of investment." The goal and concept of the "ladder of investment" focuses on decreasing the entry barriers and to achieve a maximum level of infrastructure competition which in turn gives better quality, lower prices, etc. In the long run, the new entrants will be stimulated to climb up the ladder and build out their own network in a progressive manner. By doing so, operators will decrease their reliance on the assets and the wholesale offers of incumbents.

2.3 Conclusion

Within this chapter, the existing literature concerning this work was investigated. This investigation focused on two different aspects. The first aspect involved the churn of customers, whereas the second aspect focuses on new access networks and the offering of open access.

Within the first part, an examination of churn was made. Here, churn is defined as the migration of customers to a competitor resulting in a loss of revenue for the original company. Churn can be distinguished into two major types: either involuntary or voluntary churn. The distinction between both types is based on the initiating actor for churn. If the end user initiates churn, one speaks of voluntary churn. The most given reasons for churn initiated by end users includes the price of the offer, the quality of the offer, etc. On the other hand, when the provider terminates the contract, one speaks of involuntary churn.

Next to the investigation of the types of churn, an examination was made why churn is possible. Here, competition is the major and most significant reason as to why churn can happen. Other reasons include the introduction of new technologies through innovation, the interference by regulators, etc. Finally, even though churn is an inescapable part of competition, it is rather expensive. This comes from the fact that the cost for churn is threefold. First, churn corresponds to the loss revenue, either through the loss of customers or through lowering the selling price of the service in order to remain competitive. Second, costs are related to the efforts concerning the reacquisition of lost customers or the prevention of customer churn. Third, the churn process itself will have a specific cost. It is this cost that will be examined throughout this work.

Within the second part of this chapter, new access networks were investigated. As improved telecommunication services demand for higher bandwidths, a new access network is needed. This new access network will replace the current copper and coaxial networks by fiber networks. Even though a FTTH network is the best solution as it allows for high bandwidths over large distances, the initial cost for deploying this FTTH network is very high. This high investment cost will not be covered by one actor. A multi-actor environment will arise and three different types of actors can be distinguished. Furthermore, each actor will be responsible for a different networking layer. These different layers are the physical infrastructure layer, the network layer and the service layer. The corresponding actors are the physical infrastructure provider, the network provider, and the service provider

Through the presence of multiple actors, each operating at a different network layer, sharing of infrastructure will occur and the value chain will be opened. Furthermore, competition and collaboration will arise between the different actors. The competition and collaboration within the network is realized through offering of open access. Three types can be distinguished: fiber open access, wavelength open access and bitstream open access. Open access will reduce the overall investment needed by each actor but additional costs will arise.

Chapter 3 Access networks and open access

In order to investigate the different costs associated with the churn of an end user, one must first investigate the access network that is used to deliver services to the end user. Therefore, this chapter consists of two sections. The first section examines the general form of an access network, and more specifically, that of a FTTH network. Within this section, the different possible network topologies are investigated, making a distinction between a point-to-point (P2P) and a point-to-multipoint (P2MP) network. The second section examines the components that are needed to transmit signals over the access network. Next to the investigation of the realization of an access network, an examination on how open access can be offered is performed. By describing open access, an indication is given on the needed processes that have to be completed in order for an end user to switch between providers. Two different types of open access are studied. First, fiber open access considers open access at the interface between the physical infrastructure provider and multiple network providers. Bitstream open access, on the other hand, relates to the interface between a single network provider and multiple service providers.

3.1 How is an access network realized: components and their functions

3.1.1 Examination of the possible topologies for an access network

Within a FTTH network, different topologies can be used to realize a new access network. The main difference can be seen between point-to-multipoint networks on the one hand and point-to-point networks on the other [38] [39]. This differentiation is based on using a shared feeder-fiber to serve multiple end users in case of a P2MP network, while the latter has centralized active equipment in the central office (CO) and uses a dedicated fiber per end user.

Within a P2P network, the end users are connected to the equipment in the CO by the means of a dedicated fiber. Because of the dedicated fibers, there is no need for the signals to undergo intermediate splitting and the bandwidth will not be shared between multiple end users [40]. Advantages of a P2P network include the highest bandwidth potential per end user; simplified network troubleshooting as no fibers are shared; and increased bandwidth symmetry. Disadvantages include the cost for high fiber count and increased power consumption at the CO as more active equipment is needed [41].

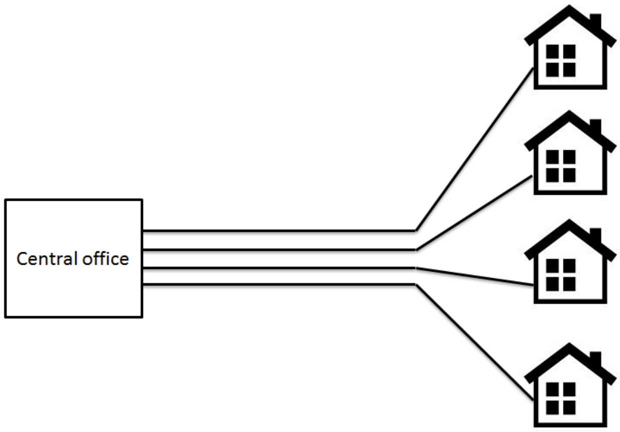

Figure 7: Visualization of a P2P network

P2MP networks make use of feeder-fibers that are shared between multiple end users. These fibers run from the CO to the street cabinet where one can find either a passive power splitter or active switching equipment. In the case of a passive power splitter, the signal is split into N equal signals towards multiple end users' fibers and broadcasted downstream. Here, N stands for the 1: N splitting factor. Since the original signal is broadcast downstream, extra encryption will be necessary to ensure the security of the transmitted data and to prevent malicious eavesdropping by other end users. Possibilities for the splitting of the bandwidth include time division multiplexing (TDM) and wavelength division multiplexing (WDM). Within TDM each end user is assigned a timeslot in which the end user can transmit signals. On the other hand, WDM uses the optical signals of different wavelengths to differentiate between end users. Advantages of a P2MP network lie with the fact of fiber consolidation and savings in the CO on space and termination equipment. A disadvantage of a P2MP network lies with the fact that one piece of defective network equipment can disrupt the service for multiple end users since equipment is shared between multiple end users. Examples of the realization of a P2MP access network include a Gigabit-capable Passive Optical Network (GPON) or an active star network.

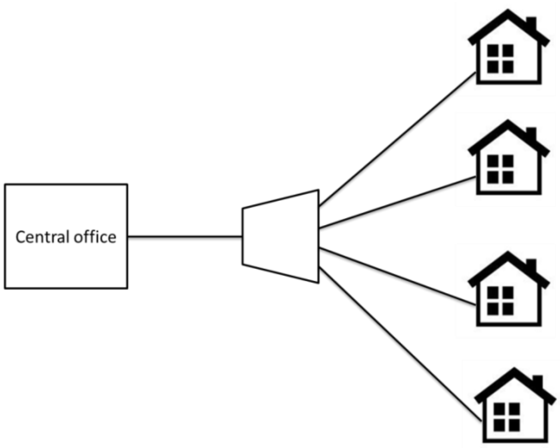

Figure 8: Visualization of a P2MP network

3.1.2 The description of a FTTH access network infrastructure

As this work focuses on the impact of churn, changes will have to be made to the access network connecting the end user with the different providers. Since these network changes related to the churn of an end user are preformed within the access network, the access network will be the point of interest. An access network is defined as the part of the telecommunications network which connects subscribers to their network provider. This corresponds to the network between the end user and the central office (CO). Within the next section, the components of the access network are described. This description starts at the Point of Interconnect (POI) and expands outwards to the end users. Even though the POI is not part of the access network it still performs a vital role in the delivery of services to the end user. As the access network can be realized through different topologies (see section 3.1.1), differences will be investigated when appropriate.

The first network segment is the POI. Within the POI, the link between the service provider (SP) and the network provider (NP) is established. Here, the SP will connect its equipment (frequently a layer 3 router) to the Ethernet aggregation switch (EAS) of the NP. The EAS is an OSI-layer 2 switch that is used to combine multiple network connections and facilitate the link between the NP and the SP. By combining multiple connections, the throughput is increased and redundancy is provided in case a single connection would fail. The aggregation of the connections occurs across multiple physical or virtual switch ports of the EAS. Note that one POI can serve multiple geographical areas and therefore multiple networks.

Next to the POI, there is the CO. The CO will acts as the starting point for the optical fiber path towards the end user and will house the needed active transmission equipment, manage all fiber terminations, and facilitate the interconnection between the optical fibers and the active equipment [42]. Here, the PIP and the NP will place their own equipment. The PIP will provide a general layout to put in all the necessary equipment while the NP will place the active equipment. This needed equipment includes optical line terminals (OLTs), cabinets, termination shelves, an optical distribution frames (ODF), cable guiding systems, uninterrupted power supplies, and equipment for climate control.

The first pieces of needed equipment are the different optical line terminals (OLTs). An OLT is a network device that serves as the endpoint of an optical network and can provide different functions. The first and major function corresponds to the conversion between optical and electrical signals. As a second major function, the OLT will coordinate the multiplexing between multiple end users. Next to the different OLTs is the optical distribution frame (ODF). The ODF is the interface between the outside plant cables and the active transmission equipment. Typically, an ODF brings together several hundred to several thousands of fibers. In most cases, the ODF offers flexible patching between active equipment ports and the field fiber connectors. Furthermore, the ODF aids in the identification and arrangement of fibers by storing them in physically separated housings or shelves. This is done to simplify fiber circuit maintenance, protect and order fibers and to avoid accidental interference to sensitive fiber circuits. Finally, the additional cabinets, shelves and guidance systems are used for equipment and fiber management as to simplify the fiber circuit maintenance and to avoid accidental interference to the fiber circuits.

Expanding outward form the CO, fibers will run towards the end users. These fibers can be split into two fiber segments. The first segment is called the feeder-fiber and runs from the CO to an intermediate street cabinet (SC). Feeder fibers can cover a few km of distance before being terminated and generally consist of a larger fiber count to provide the necessary fiber capacity [42]. The second segment corresponds to the different distribution fibers and runs from the street cabinet to the different end users. Within the street cabinet, the larger feeder cables are converted into smaller distribution cables. In order to minimize further construction costs, this street cabinet should be close to the end users as to shorten the subsequent distribution cables. The street cabinets are often placed for relatively easy access to the fiber circuits. As street cabinets are easily accessible, security and protection must also be included to prevent physical tampering. As a P2P topology uses dedicated fibers, the street cabinet will be used as a regular flexibility point to enable the controlling and repairing of fibers. Within a P2MP topology, this street cabinet will house the needed splitters. These splitters ensure the distribution of the signal into multiple signals to reach all end users.

The final part of the access network is found at the customer's premises. Here, an optical network terminal (ONT) also referred to as an Optical Network Unit (ONU), is used to terminate the optical fiber. It furthermore converts the optical signal into an electrical one and performs the multiplexing/demultiplexing of the signal into the different components.

Figure 9 and Figure 10 will give a visual representation of the access network.

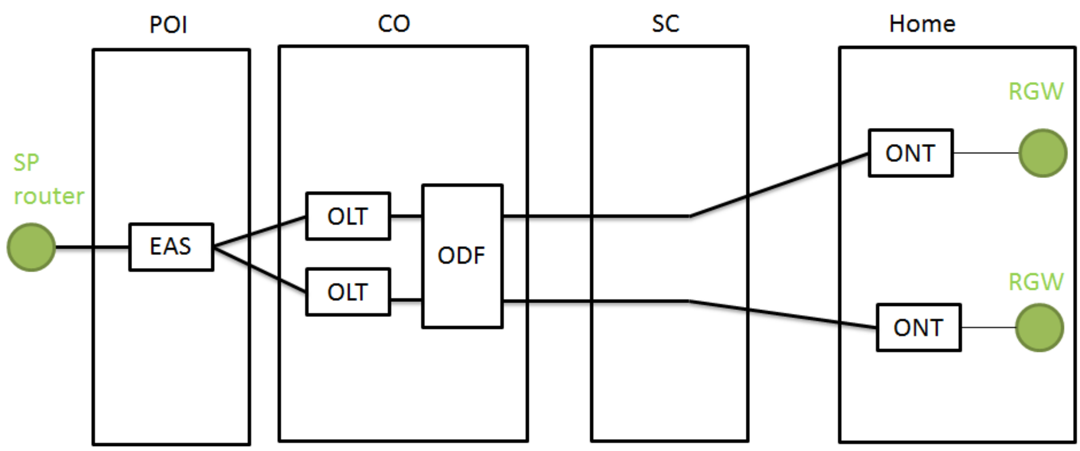

Figure 9: Access network for a P2P topology with only one NP

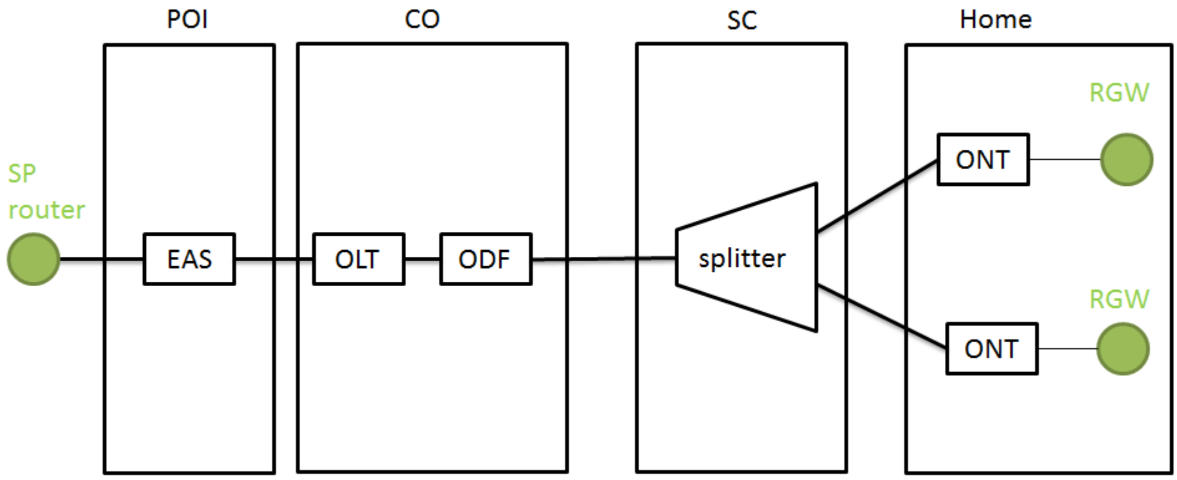

Figure 10: Access network for a P2MP topology with one NP

In order to provide services to different end users, the SP should install a residential gateway (RGW) at the end user side and connect it to the ONT, which is installed by the chosen NP. The RGW is used to link the end user to the SP and to receive services. The installation of an RGW does not necessarily require a physical visit from a technician. If this is easy and well documented, the connection and installation of the RGW could be done by the end user itself, which will reduce the costs significantly.

There are two options for the connection RGW-ONT. "Specifically a given access network may use an ONT that is owned and managed by the network provider or it may support a wires-only delivery to the end user's premises. In this context, "wires-only" means the ONT is a passive device such as a wall socket" [36]. With the first option, the NP will place the ONT while the SP will place the RGW. This option gives a clearer separation between the different functionalities of the ONT and the RGW and will therefore be used in this work. In case of a "wires-only" solution the equipment at the end user's premises will consist of one box and this single piece of equipment will act as both the physical line termination and the residential gateway. This one box will be provided, configured and managed by the SP. Advantages of this one box solution are the fact that it will be cheaper, consumes less power, less space and may therefore be seen as more suitable by customers. A disadvantage of the "wires only" implementation is the fact that interoperability has to be established. It furthermore complicates the provisioning of services from multiple SPs.

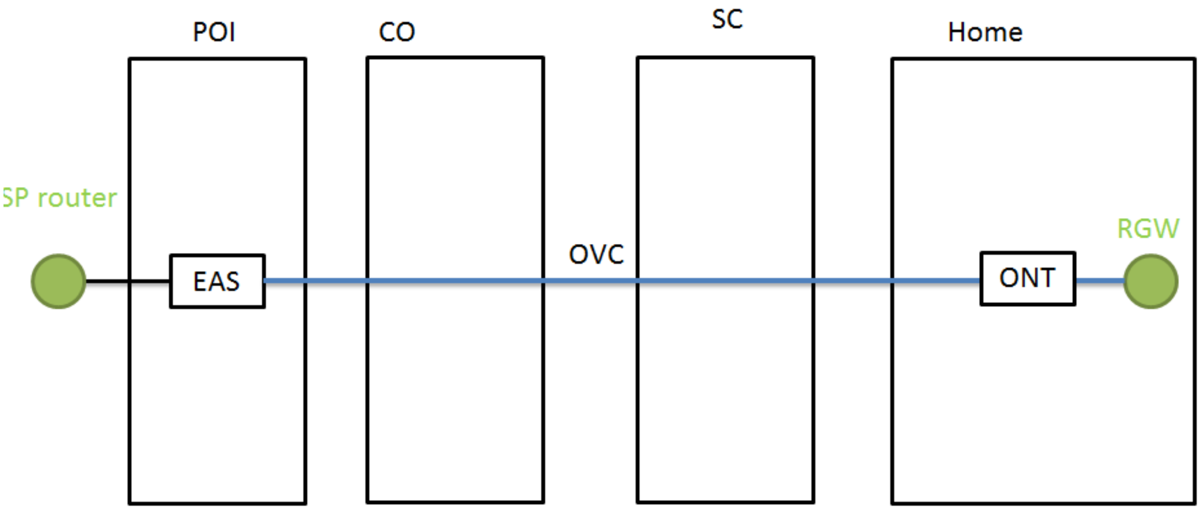

Figure 11: Reference scenario for one service provider

3.2 How can open access be offered over a FTTH network: Description of fiber and bitstream open access

Within this section, a description is given on how open access can be offered within an access network. The investigation of the technical description of open access will aid in the identification of the needed processes for customer churn as well as to identify the difference in cost for churn. Three types of open access can be identified: fiber, wavelength, and bitstream open access. Fiber and wavelength open access consider open access at the interface between the physical infrastructure provider and the network provider. Bitstream open access, on the other hand, relates to the interface between the network provider and the service provider. Two types of open access will be taken into account, i.e. fiber and bitstream open access. Wavelength open access will not be described as it is only used on a very small scale [44]. An example of fiber open access being used can be found with Stokab in Sweden [30] while example of bitstream open access can be found within Germany, Spain, United Kingdom, etc. [36].

3.2.1 Fiber open access

Fiber open access allows multiple network providers (NPs) on top of one physical infrastructure provider (PIP). Hereby, the PIP is responsible for the passive infrastructure (layer 1), meaning the trenches, ducts, fibers, and passive equipment like power splitters in the street cabinets.

As the type of fiber open access is influenced by the topology that is being used in a network, this section will describe the considered topologies. Theoretically, there is no upper limit to the number of competing NPs in fiber open access but the assumption was made that never more than five NPs will be active in the same geographical area at the same point in time. This is because the maximum number of NPs per area is limited by the number of feeder fibers that serve the street cabinets, which is around five in realistic scenarios [44].

Open access within a P2P topology

When open access is offered, multiple NPs are allowed to install their own equipment. The difference between the single and multi NP network when it comes to a P2P network only lies within the Central Office. Here, an additional patch panel must be installed. This patch panel is used to connect the different NPs to the different dedicated fibers as it will function as a cross-bridge between the fiber termination side of the PIP and the system side of the NP. The ODF, already present in the case of one NP and used to keep the fibers ordered and clean, can also function as the patch panel. Since each end user has a dedicated fiber to the central office available, the size of the ODF that performs the function of a patch panel (both in terms of patches and ODF slots) equals the numbers of end users served by the central office. The number of end users per central office is typically in the order of 20,000 [33]. Furthermore, separate, lockable system racks will have to be installed. These system racks will contain NP-specific equipment and can be locked to prevent physical tampering.

At the end user's premises, no extra equipment will be needed when open access is offered.

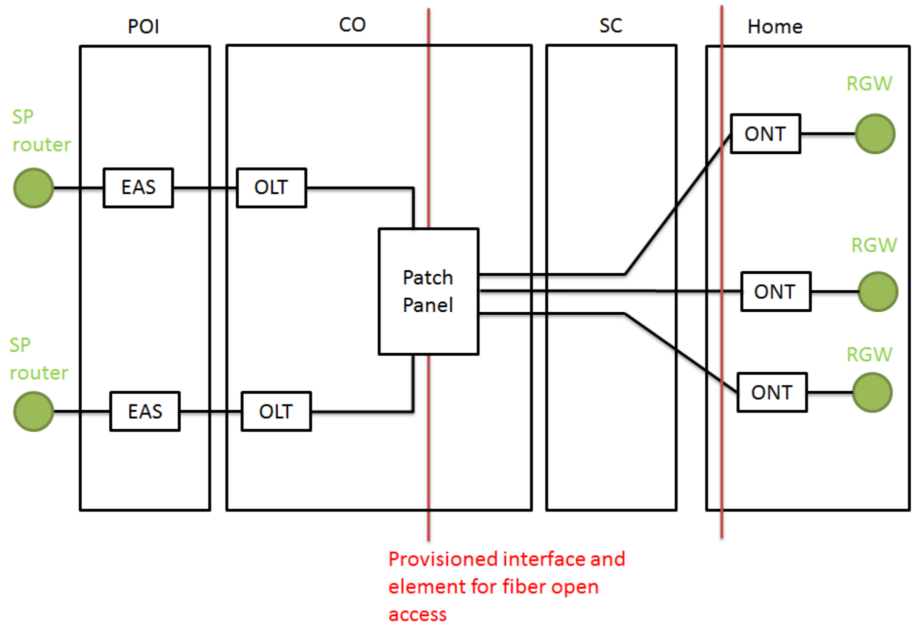

Figure 12: P2P open access scenario with the presence of multiple NPs

Impact of open access in a P2P topology on the churn of end users

Churn within fiber open access represents the case where an end user wants to switch network providers. The churn of an end user requires at least two "truck rolls." Here, a truck roll corresponds to the transportation of a technician to perform manual labor on site. One manual intervention happens at the end user's premises, where the ONT needs to be replaced. A reason for the change in ONTs can be the use of different technologies by the

NPs. Since the changing of ONTs can involve a new splicing of the fiber, it will be hard for end users that want to do it themselves. The most important factor is “fiber hygiene,” where the end users’ fingerprints might compromise the proper function of the fiber, and this due to inexperience with the procedure. Here, splicing is defined as joining two fiber ends together in order to form a new continuous fiber over which optical signals can be transmitted. Two splicing methods are accepted: fusion splicing and mechanical splicing [45]. Fusion splicing welds the two fibers together using an electric arc. Mechanical splicing on the other hand uses a fixture to hold the two fibers together. Mechanical splicing is quicker and easier than fusion splicing but the optical splice loss is greater and the connection is less robust. However, the splicing procedure can be optimized when using fiber connectors. Here, the fiber connectors will be installed when the end user first connects to the service and no more fiber splicing is needed. The other manual intervention happens at the central office, where a manual re-patching needs to be done at the patch panel to connect the end user to the new NP. Apart from the costs, this type of churn also entails other barriers for the user: the process can take up to a day, resulting in significant outage time, and since the process requires manual labor at the home of the end user, the end user needs to be available at the premises.

Open access within a P2MP topology

Fiber open access in a P2MP topology with multiple feeder fibers, where the number of feeder fibers equals the number of possible NPs, will influence the equipment in the street cabinets. A NP-specific power splitter will have to be installed in the street cabinets. From the CO onward, NP-specific feeder fibers will run towards the different street cabinets and will be connected to the NP-specific splitter. Dedicated distribution fibers will run from these NP-specific splitters to the end user’s premises. Furthermore, the installation of the NP-specific power splitter will also have an impact when an end user churns.

A different, but less scalable approach may be applied if the PIP provides multiple distribution/drop fibers per premise, either voluntarily or regulated by the government. In this case, the switching between different NPs may occur at the end user’s premises. The available distribution fibers will already be connected to the different NP-specific splitters and a fiber switchbox will be installed at the end user’s premises. The connection to a NP or the switching to a different NP can therefore be made by switching to a different fiber in the switchbox. As this approach is less scalable and needs the installation of multiple fibers per premise, this option will not be taken into account, but is mentioned for completeness [46].

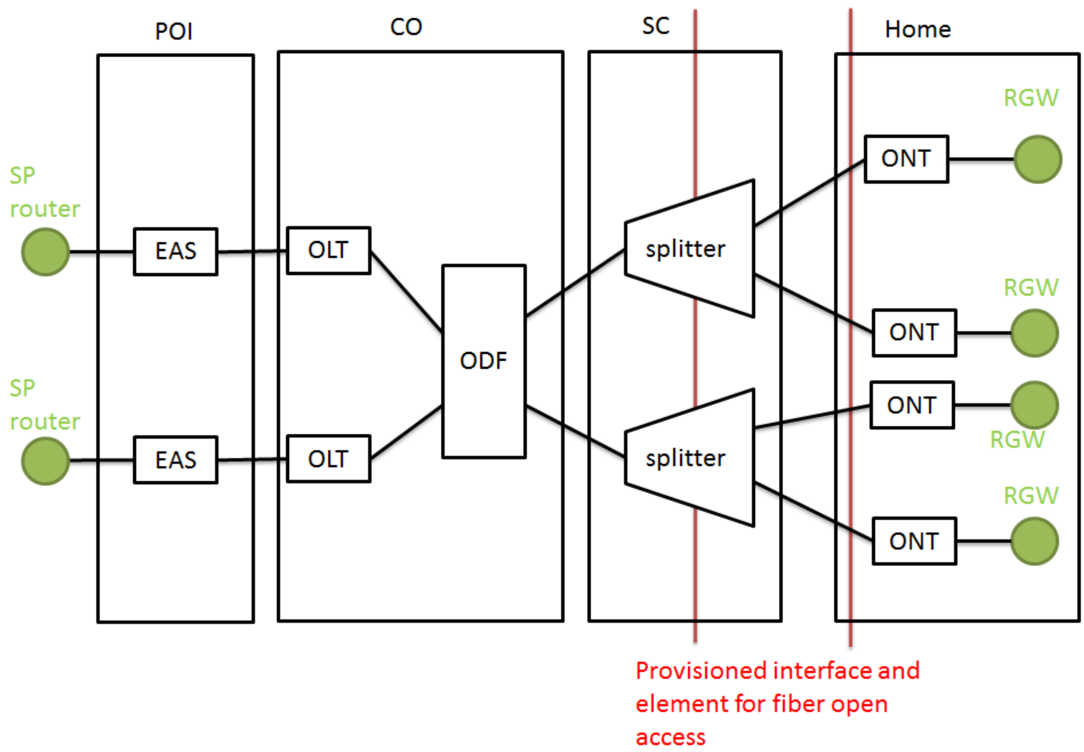

Figure 13: P2MP open access scenario with multiple NPs

Impact of open access in a P2MP topology on the churn of end users

Similar to a P2P topology, the churn of an end user requires at least two "truck rolls." One manual intervention happens at the end user's premises, where the ONT needs to be replaced. This intervention is equal within both topologies. The other manual intervention happens at the street cabinet. Here, the dedicated fiber from the end user's premises to the street cabinet will need to be connected to the correct NP-specific splitter. This connection can be made through the use of a fiber splice or with a fiber connector.

3.2.2 Bitstream open access

Bitstream open access is offered at the interface between the NP and the SP. This means that one NP will offer end-to-end connectivity to multiple SPs. Two types of bitstream open access exist and the classification of the different types depends on the specific layer of activity within the OSI-stack. There is layer 2 Ethernet bitstream and layer 3 IP bitstream open access. Within both types of open access, a secure bandwidth pipe is provided and therefore both can be treated similarly [44]. With layer 2 bitstream, the different SPs connect to the Ethernet aggregation switch (EAS) of a NP while for layer 3 bitstream the SPs connect to the layer 3 router of a NP. Within this work, the focus will be on layer 2 bitstream.

Bitstream open access can be offered over any topology, as it is technology-agnostic of the used network technology because it only considers the endpoints. To gain access on bitstream layer, an interface needs to be provided at both the end user side and the Point of

Interconnect. The interfaces are defined according to the Metro Ethernet Forum (MEF). At the Point of Interconnect, the implemented interface is the External Network-Network Interface (E-NNI) standard [47] and allows for a 1 Gigabit or 10 Gigabit interface carrying multiplexed traffic streams. Within [48] the E-NNI is defined as the reference point that represents the boundary between two operator networks that are operated as separate administrative domains. The E-NNI is considered to be the physical and logical demarcation point for the offered services and is implemented at the EAS. It furthermore represents the boundary between two operators. On the end user side, the User Network Interface (UNI) will be the demarcation point.

An operator virtual circuit (OVC) will be used to associate a UNI and an E-NNI, independent of the design of the network. Within [47], an OVC is listed as "the association between external interfaces (UNIs or E-NNIs) of a single operator network such that any customer frame mapped to an OVC at one interface may be delivered to any other interface that is mapped onto the same OVC" [47]. Here, a virtual circuit is defined as a way of transporting data over a packet switched computer network in such a way that it would appear as if the data was transmitted over a dedicated physical link. Within a layer 2 Ethernet virtual circuit, the data is always delivered over the same network path. Furthermore, the virtual circuit is connection oriented meaning that data will arrive in the same order as it was sent. This fixed delivery path has the advantage that a certain amount of bandwidth can be reserved to transmit the data. Priority can be given to certain types of content. Furthermore, less packet headers are required as a small channel identifier. This identifier is based on Customer Edge VLAN IDs [48], where there are 4095 Customer Edge VLAN IDs (CE-VLAN ID) per service identifier. In order to identify the service, an S-VLAN ID is used. This S-tag allows the operator on either side of the E-NNI to map frames to the appropriate OVC. As a result, the combination of an S-VLAN ID and the CE-VLAN ID correspond to one single OVC or alternatively the path that is used to deliver a service from a SP to the end user.

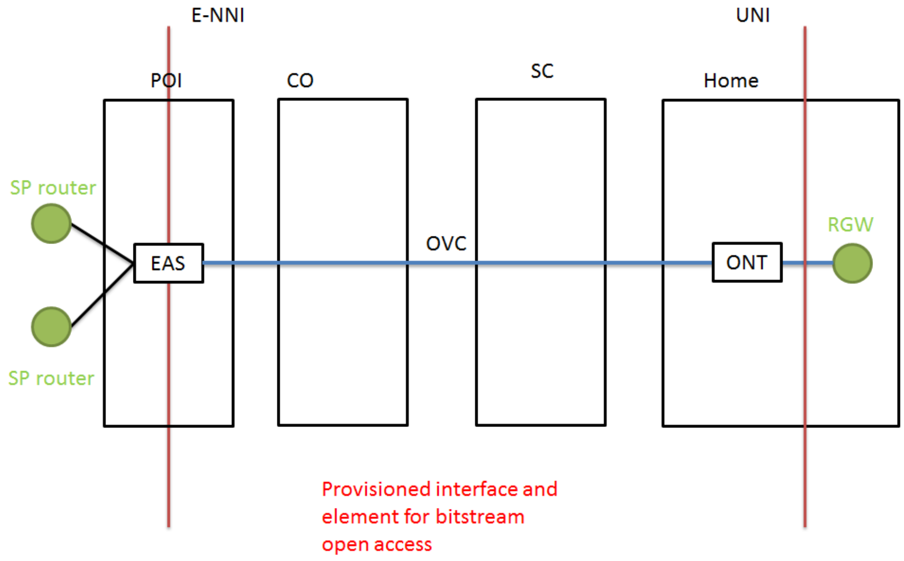

Figure 14: Layer 2 Bitstream view over the access network

Impact of bitstream open access on the churn of end users

In contrast to fiber open access, churning an end user to an alternative SP does not involve any manual labor at the service provider system side. It basically comes down to a business-to-business interaction and only involves a software configuration: the connection of the right EAS port, which is a virtual port, to the right SP. Next to the software configuration, the RGW of the end user should be switched, as different providers might use different technologies. This switch in equipment can be done by a SP technician, who induces a "truck roll" to the end user's premise or by the end user itself if well documented and easy. Changing SPs thus involves the installation of a new RGW and a software configuration of the EAS-SP router link.

3.3 Conclusion

Within this chapter, the realization of a new access network and the different types of open access are investigated. The first section covered the different topologies of the access network. The two possible topologies are a P2P and a P2MP topology. Within a P2P topology, a dedicated fiber is assigned to each end user. On the other hand, a P2MP topology uses fibers that are shared between multiple end users.

Next to the investigation of the different topologies, a study was made between the different components of an access network. Here, an access network was defined as the part of the telecommunications network, which connects subscribers to their network provider. The first network segment that is closely related to the access network is the Point of Interconnect. Here, an Ethernet Aggregation Switch will provide the link between a network provider and a service provider. The next network segment consists of the central office. Within the central office, the active transmission equipment and supportive equipment is stored. The OLT will transmit optical signals through the FTTH network. The ODF will be used to terminate the fibers and it offers flexible patching. At the end user segment of the access network, an ONT will convert the optical signal back to an electric signal. Furthermore, an RGW will be used to receive the services of the SP.

After the examination of an access network, the different types of open access were considered. A study of the types of open access is made to identify the necessary processes that are needed to complete the churn of an end user. Two types of open access were considered. The first type of open access is fiber open access and allows the connection of multiple network providers on top of a single physical infrastructure provider. The second type of open access is bitstream open access and allows multiple service providers on top of one network provider. Fiber open access can be further differentiated based on the topology used. Within a P2P topology, a patch panel is introduced at the central office and in case of churn, a new fiber patch must be performed at this patch panel. Within a P2MP topology, a NP-specific splitter is installed at each street cabinet. When an end user churns, the distribution fiber of the end user must be patched to the right splitter. Alongside the different patches, a new ONT must be installed at the end user's premises as different NPs might use different technologies.

Bitstream open access is, in contrast to fiber open access, independent of the used topology and technology. Therefore, bitstream open access requires less equipment and manual processes as it mostly involves software configurations. As a result, the churning of end users within bitstream open access involves the configuration of the virtual circuit between the service provider and the end user, as well as the replacement of the RGW of the end user.

Chapter 4 Identification of costs in churn process

In order to model the costs for churn, one must identify the different cost drivers within the churn procedures. The identification of the cost drivers for churn is done through the description of the different churn procedures. Two churn procedures can be distinguished. The first procedure concerns an end user switching service providers, while the second procedure is applied to an end user switching network providers. Furthermore, switching network providers is dependent on the used network topology and a separation is made between a P2P and a P2MP topology. Alongside the identification of costs, one can classify these costs. Classifying the costs per actor will show the impact of churn on the different actors involved. On the other hand, classifying the costs into different category will show the distinctive nature of the involved costs. Furthermore, the classification of costs will aid in the optimization of the cost as a theoretical optimizations can be applied to an entire class of costs (see Chapter 6). Therefore, this chapter will start with the definition of a cost breakdown structure in which all present churn costs can be classified. After the definition of this structure, the procedures for churning are described. Each description will focus on the different sub-steps that need to be performed.

4.1 Definition of the cost breakdown structure used in this work

A tree shaped breakdown structure is chosen to define the cost breakdown used in this work. The cost for the churn of an end user can be split into different categories, which makes the hierarchical nature of a tree very suited. Here, the cost for churn can be split into three different branches: equipment costs, process costs, and transaction costs.

Equipment cost will relate to the equipment needed for the end user to connect to the access network, receive a service, or to facilitate an installation. Processes costs correspond to actions that need to be performed in order to facilitate the switch of the end user. The final branch will be transaction costs. Transaction costs are related to the cooperation between different providers and were first defined by Williamson [49]. Within the transaction cost framework, it is stated that the transaction is seen as the basic unit of economic analysis and that “a transaction occurs when a good or service is transferred across a technologically separable interface” [49]. The whole cost breakdown structure is visualized in Figure 15.

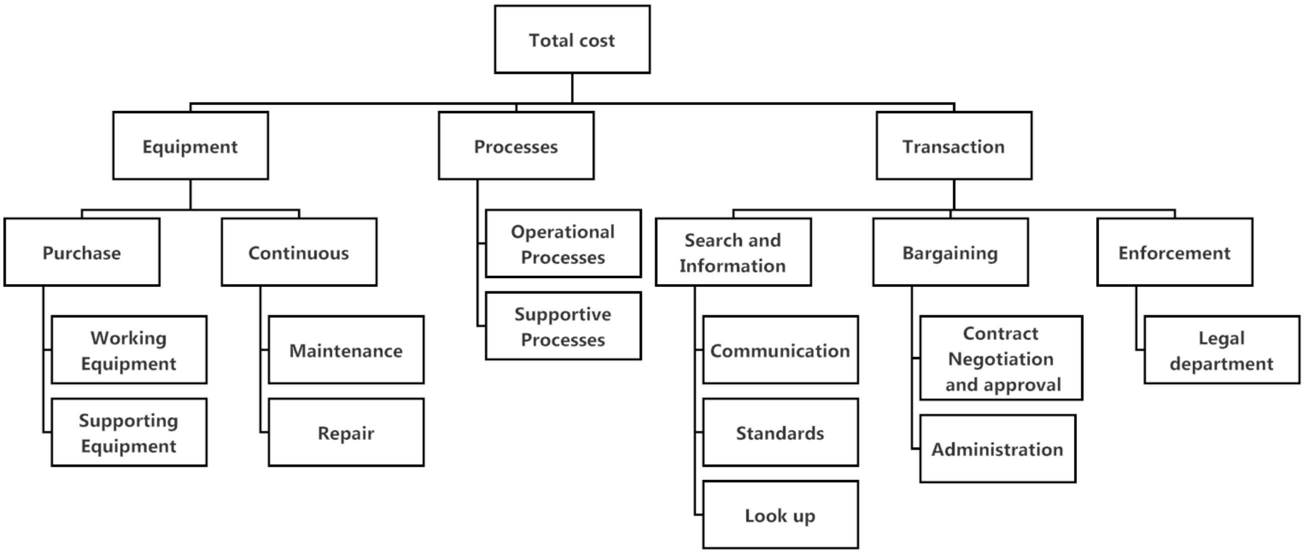

Figure 15: Cost breakdown structure used in this work

In the following section, each cost block will be defined and examples will be given. These examples will be, for clarification, applied to a FTTH deployment.

4.1.1 Equipment costs

- Purchasing equipment: one-time costs related to the purchase of equipment
  - Working equipment: Costs related to the purchase of equipment that is needed to perform core tasks within a business or a project. Examples include ONTs or RGWs within a network.
  - Supporting equipment: Costs considering the purchase of equipment in order to support core items. Examples for this cost block contain system racks to place equipment in, cooling equipment, additional patch slots etc.

- Continuous cost: Costs related to the operational phase. These costs are needed for the day-by-day operations. Churn does not include any day-by-day operations but these costs are introduced for completeness.
  - Maintenance: The purchased equipment will need maintenance. This cost is often modeled as a percentage of the purchase price. The usage of a percentage can be seen as the closing of a maintenance contract with the supplier of the equipment.
  - Repair and replacement: When equipment is broken, it needs to be repaired and/or replaced.

4.1.2 Process costs

- Operational processes: Costs related to core business and that create the primary value stream. Network examples include the patching of fibers, making a software connection, setting up a virtual circuit, etc.

- Supportive processes: Cost considering processes that are needed in order to perform operational processes. A specific example includes the transportation of goods and people.

4.1.3 Transaction costs

- Search and information costs: Costs related to the reduction of information asymmetry.
    - Communication: Costs concerning the communication between different parties. When different parties collaborate, good communication ensures the delivery of the right information to the responsible party.
    - Standards: Costs considering the definition and utilization of standards. These costs include the writing of standards as well as the search costs related to the equipment or protocols following a certain standard.
    - Look up: Cost related to the search of the needed information. This information includes details of the offers, prices, contact information, etc.

- Bargaining costs: Costs related to the settling of contracts.
    - Contract negotiations and approval: Costs related to the negotiation of the contracts between the different parties and the approval of these contracts. As end users will not have a significant negotiation power, both the negotiating and the approval of the contract are considered simultaneously.
    - Administrative subscription and termination: Customers have to be subscribed to a provider before acquiring a good or a service. Within these costs, the customer provides sufficient information for a successful delivery of the good or service. On the other hand, when a customer wants to terminate his contract, the provider must administratively terminate its contract.

- Enforcement costs: Costs acquired when making sure that everything is done as agreed upon.
    - Legal department: Costs related to the hiring of a legal force to follow up on lawsuits, contracts, etc. Lawyers should only be needed when drafting inter-company contracts or when customers do not pay their bills. The enforcement costs are therefore only included for completeness.

4.2 The description of the churn procedures and the identification and classification of cost drivers

Within this section a detailed and qualitative description of the different churn processes will be given. The churn of an end user is a repetitive process independent of the churning end user. Therefore, it can also be visually represented in a flow chart. This visual representation is based on the Business Process Model and Notation (BPMN) [50]. The BPMN representation provides businesses with the capability of understanding their internal business procedures in a graphical notation and will give organizations the ability to communicate these procedures in a standard manner. Furthermore, the graphical notation will facilitate the understanding of the performance collaborations and business transactions between the organizations [50]. Reasons for using BPMN include the fact that it is standardized, simple, developed to support a technical implementation, and its power to express how the process functions. A process model within BPMN is built around three building blocks each having a distinct function and visual representation [50], [51]. These blocks are events, activities, and gateway. Events indicate start, intermediate, and end points of the process. Activities, on the other hand, indicate actions that have to be performed during the process. Finally, gateways will indicate splits or joins in the process flow. These splits and joins indicate either multiple paths that have to be taken within the process, or decisions that have to be made depending on the situation.

Next to the visual representation of the processes, the different costs within the churn procedure must be identified and assigned to a cost driver. Here, a cost driver is defined as the determining factor for the cost of an activity. Furthermore, each different cost category from the cost breakdown structure will be calculated in a different way. This cost can be either fixed or variable. Equipment costs will be seen as a fixed. This means that the used equipment has a fixed cost, independent of the considered scenario. Examples include the fixed cost of an RGW or an ONT. The type of process costs will determine its calculation method. The first process cost of transportation, which is a supportive process, is calculated by the round trip time that is needed. Operational processes on the other hand are calculated as a fixed cost for the entire process, or through activity based costing. The last cost category, transaction costs, is calculated through time-driven activity-based costing.

Activity based costing is a costing methodology that calculates the cost of an activity, in this case a process or a transaction, by assigning resources to this activity. The cost is then estimated by the unit cost of the resource and the consumption of this resource. The consumption rate and the cost of the resource are estimated through interviews, observations, etc. However, activity based costing has its shortcomings. These shortcomings of the activity based costing model result from the fact that it is less scalable to entire companies. Interviewing employees throughout a large company is very time consuming and costly. Furthermore, if processes change, the whole costing process must be redone.

Time-driven activity based costing is a variation that emerged out of activity based costing to compensate for its short comings and is useable for both processes and transactions [52]. Time-driven activity-based costing mainly has two required parameters: The unit cost of the supplying capacity and the time required to perform the transaction or the process. By using time-driven activity-based costing, the cost for a transaction is determined as the time spent on performing the transaction/process and the hourly labor rate of the person performing the transaction/process. As a result, the time-driven activity-based costing is more scalable than regular activity based costing. Introducing a new process or reworking the model is performed easily. Managers can simply estimate the unit time required for each new activity and update the model accordingly [52].

4.2.1 Churn process for an end user switching to a new network provider

The next section describes the churn process for an end user switching to a new network provider within fiber open access. Within the description of the procedure, a list of sequential and successive steps is given and completing all steps will result in the successful completion of a churn process. For each step in a procedure a detailed description is given alongside the determining cost factors. The initiation for an end user switching network providers can happen in two distinctive ways. The first possibility is through the end users. Here, the end user decides on both service provider and network provider, and can switch network providers on its own. A second possibility is made by the service provider. Here, the end user only chooses the service provider and the service provider in turn will choose the network provider. Within this work, only the option where the end users can choose both the network provider and the service provider will be discussed. This results from believing that a customer should have the freedom to choose both his network and service provider.

Furthermore, Figure 16 (P2MP topology) and Figure 17 (P2P topology) show the network before and after the completion of the churn procedure. These figures also give an indication of the changes that have to be made to the access network during the churn procedure. Figure 18 visualizes the BPMN flowchart for an end user churning network providers and gives a detailed overview of the procedure.

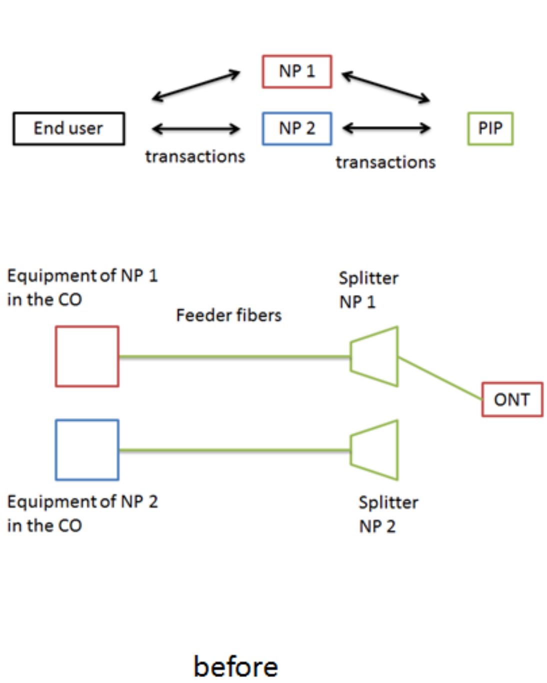

Figure 16: Network figure for an end user switching network provider for a P2MP topology

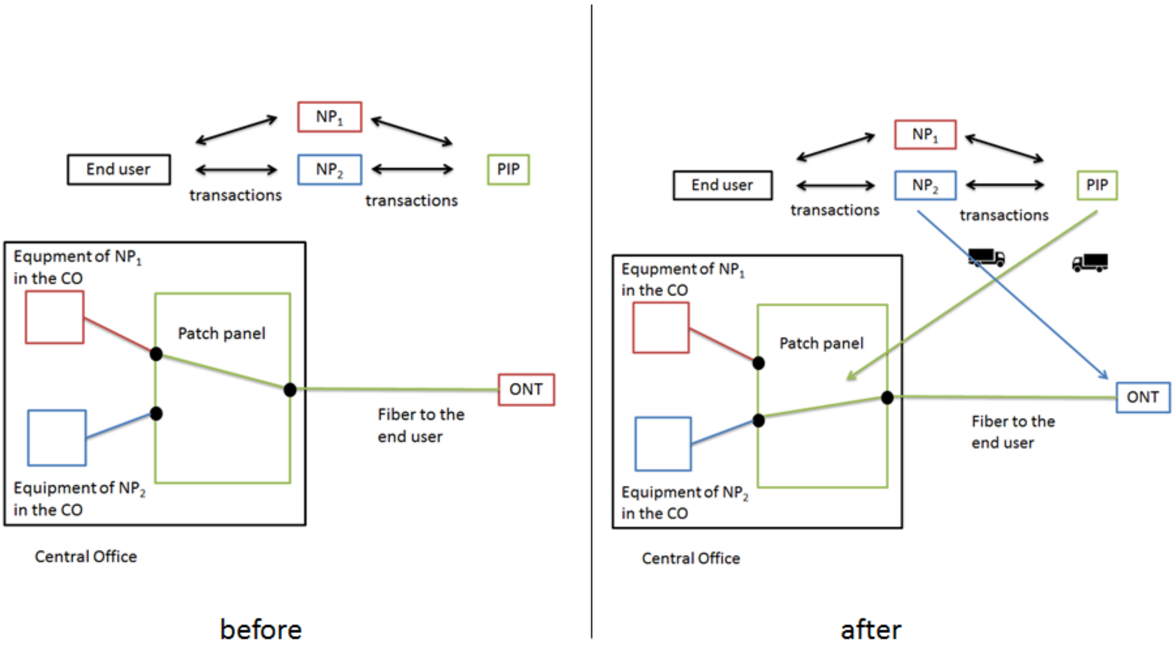

Figure 17: Network figure for an end user switching network provider for a P2P topology

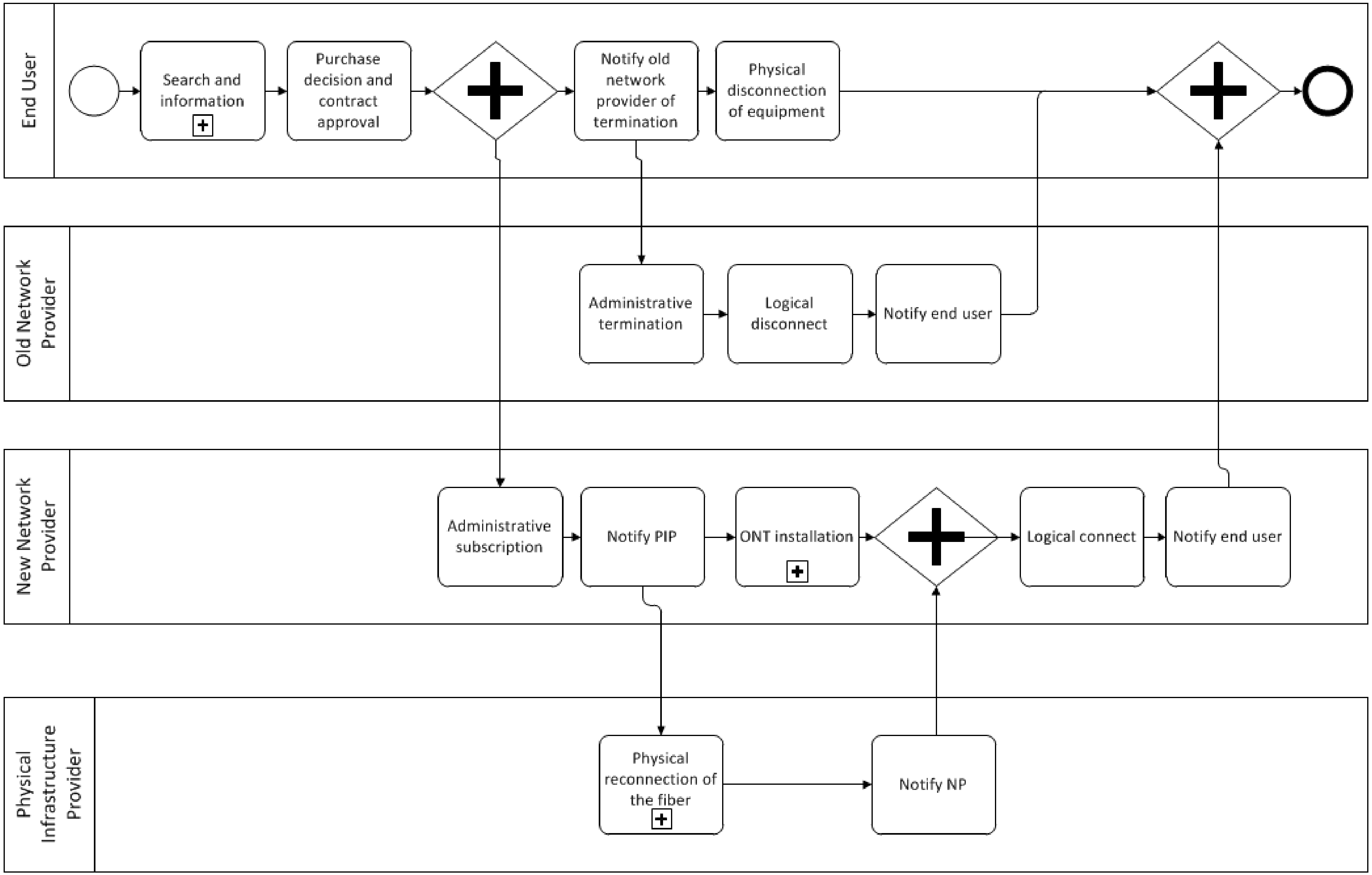

Figure 18: BPMN flowchart for an end user churning between network providers

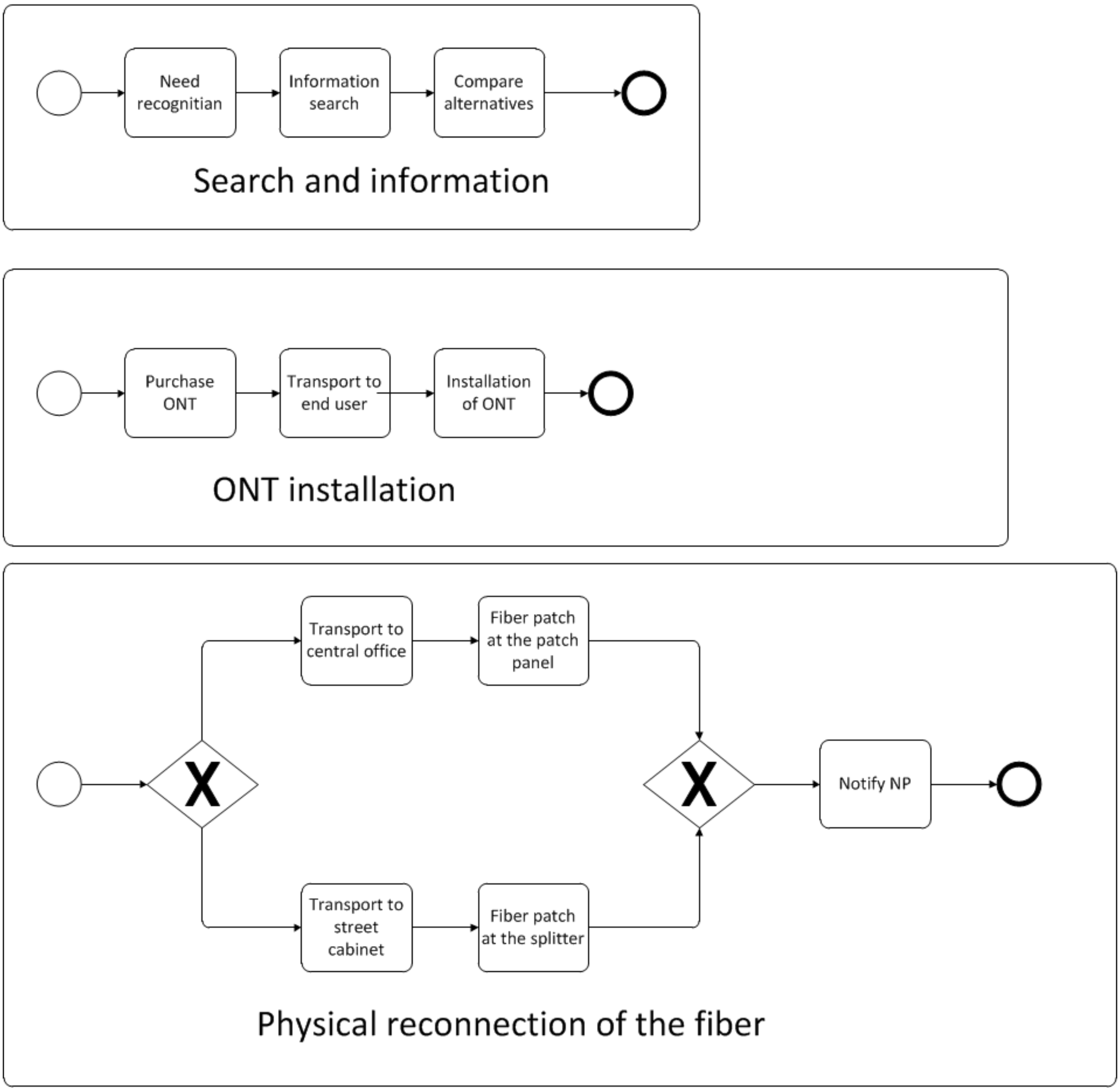

Figure 19: BPMN flowchart for the sub-processes when an end user churns network providers

Detailed description for an end user switching network provider

1. The end user wants to churn and will look for alternative offers.

The first step in the churn procedure is initiated by the end user and consists of three smaller steps: need recognition, information search, and alternative evaluation [53]. The decision to churn arises from the need recognition of the end user. The end user is dissatisfied with the current service or is forced to churn by the network provider (see chapter 2.1.2 for the different churn reasons. Once the end user has decided he wants to churn, the search for information about alternatives will start. This search can be performed online on web sites of different providers, using advertisement leaflets, reviews from other end users, etc. Once the end user has collected all the information, the evaluation of the different alternatives will begin. The end user will look for the most suitable alternative that fits his needs best. Need recognition will not be taken up into the cost calculation because this can differ heavily from end user to end user.

$$\mathbf{Cost} = (\mathbf{time\ spent\ on\ search\ for\ alternatives} + \mathbf{time\ spent\ on\ comparing\ offers})\ \mathbf{x}\ \frac{\mathbf{labor\ cost\ end\ user}}{\mathbf{hour}}$$

Cost classification: transaction: search and information
Cost actor: End user

2. Purchase decision by the end user and contract approval with the network provider

Once all alternatives are compared to each other, the end user will decide which offer he will purchase. After the decision is made, the end user will contact the provider and order a request for connectivity through the network of the alternative NP. As the end user does not have much bargaining power, he can only agree on the terms stated by the NP. The end user will only be able to negotiate in case he is a large customer with very specific demands (e.g. business customer). When the order by the end user is submitted, the provider has two options. The provider accepts the request and supplies the services to the end user. On the other hand, the provider can reject the request. In this case, the end user has to choose another provider. Reasons for rejection can include the fact that the provider is not active in the geographical area of the end user, the end user has no financial credibility, etc.

Every end user will place an order, which can be classified as a bargaining cost, and more specific as a contract negotiation and approval costs. However, for most end users, this will only entail an approval component. The cost for this step can be calculated as the time spent on contract approval times the unit labor of an end user.

$$\mathbf{Cost} = \mathbf{time\ spent\ on\ contract\ approval}\ \mathbf{x}\ \frac{\mathbf{labor\ cost\ end\ user}}{\mathbf{hour}}$$

Cost classification: transaction: bargaining: contract approval
Cost actor: End user

3. The notification of the termination of the current contract

Once the contract is signed with the new NP (NP_2), the end user will have to terminate the contract with the current network provider (NP_1). This can be done by notifying NP_1 with a written letter, filling in a digital form on the network provider's homepage, etc. The end user should also respect the termination clause of the original contract. This is important as most contracts state that an end user must give notice a specific number of days prior to terminating the contract. Otherwise, NP_1 could charge a penalty for not following the right procedure. The cost for this step will be calculated as the time spent on generating the notification times the unit labor cost of an end user.

Next to the notification, the end user will physically disconnect the equipment. The disconnection of the equipment can occur fast and easy. As a result, the end user is capable to perform this step on his own.

$$\mathbf{Cost} = (\mathbf{time\ spent\ on\ a\ end\ user\_provider\ notification}\ (\mathbf{1}) + \mathbf{time\ for\ physical\ disconnect}\ (\mathbf{2})\ )\ \mathbf{x}\ \frac{\mathbf{labor\ cost\ end\ user}}{\mathbf{hour}}$$

Cost classification: transaction: search and information: communication (1)
Processes: operational processes (2)
Cost actor: End user

4. The termination of the current contract by the original network provider

If the network provider receives a timely notification, NP_1 will terminate the contract. The termination of the contract will consist of two parts. The first part will be the administrative termination of the end user's contract. Within this step, the NP will assign a final cost, distribute the final bill, and check if all bills have been paid. The assignment of the final cost corresponds to the assignment of a contract termination fee and penalty fees. The contract termination fee corresponds to an additional cost that is charged when the contract is prematurely ended. However, this termination fee is regulator sensitive (see section 2.1.6). Penalty fees, on the other hand, correspond to the end user not complying with contract details. Examples include the charging of a penalty fee if the equipment is not returned and the charging of a fee if not enough notice is taken into account. After the assignment of final costs, NP_1 will distribute a final bill. A final aspect of the administrative termination is the payment checking. The NP will check if all bills have been paid. If the payment is late, the NP will send reminders or undertake legal actions. The cost for this administrative termination is determined as the product of the time spent on administrative termination and the unit labor cost of a customer service employee.

The second part of the termination of the contract consists of the logical disconnection of the end user. Here, the NP will perform a software operation and exclude the end user from the operational system, which in turn results in not receiving any service or in this case end-to-end connectivity. As a result, the end user will not be able to use the previous end-to-end connectivity even though he might still be physically connected to the network of NP_1. The cost for the logical disconnection equals the product of the time needed for setting up a logical connection times a corrective factor and the unit labor cost of a network operator. The corrective factor corresponds to the fact that a logical disconnection is similar to a logical connection except that no testing is required.

$$\begin{aligned}\textbf{Cost} &= \textbf{time of administrative termination x } \frac{\textbf{labor cost customer service}}{\textbf{hour}} \; (\mathbf{1}) \\ &+ \textbf{ time of logical connection x correction x } \frac{\textbf{labor cost network operator}}{\textbf{hour}} \; (\mathbf{2})\end{aligned}$$

Cost classification: (1) Transaction: Bargaining: Administration
(2) Processes: Operational processes
Cost actor: Original NP (NP_1)

5. The original network provider will notify the end user that the contract is terminated

After the administrative termination and the logical disconnect, the original service provider will notify the end user that the contract is terminated. The service provider can already include additional details within this notification. For example, if the end user has not returned his (rented) ONT, a first reminder can be included within the acknowledgement of the termination of the contract. The cost for this notification is determined as the product of the time spent generating this notification and the unit labor cost of a customer service employee.

$$\textbf{Cost} = \textbf{time for a end user\_provider notification x } \frac{\textbf{labor cost customer service}}{\textbf{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: Original NP (NP_1)

6. The administrative subscription of the end user by the new NP (NP_2)

If the network provider accepts the order, the end user will be administratively subscribed to the network provider. The first part of this administrative subscription is the contract handling. Here, the network provider will process the signed contract and add the end user to the database. The database entry should require the following fields: personal details about the end user, address information, starting date of the contract, billing information, etc. Furthermore, the date of the installation will be set. By setting this date, the NP and end user will make sure that end user will be home when a technician visits. This is done to avoid multiple truck rolls of the technician towards the end user's premise. An additional and important aspect of the end user information is a listing of the connected service provider of the end user. This way, the continuity of services is guaranteed. An example of a database entry is given in Table 1.

After the contract handling, the NP will assign the different costs to the customer's account. This can include the monthly subscription cost, the cost for the installation, and the cost for equipment. An example of the assigned equipment cost can be found if the NPs technician will bring a new ONT to the end user's premise. The final part of the administrative subscription consists of the distribution of the first bill. This first bill will include the installation costs. The cost for this administrative subscription step will be calculated as the time spent on the administrative subscription times the labor cost for a customer service employee. Furthermore, the time spent on administrative subscription equals the summation of the contract handling time, the time needed for the cost assignment and the time needed to distribute the first bill.

Table 1: Example of a database entry based on [85]

Database entry for an end user.	
Personal information	• Customer ID • Customer name • Date of birth • Address • Billing information
Service details	• Type of connectivity • Date of ONT installation • Starting date of the contract/connectivity
Connected services	List of connected Service Providers

$$\mathbf{Cost} = \mathbf{time\ spent\ on\ administrative\ subscription\ x}\ \frac{\mathbf{labor\ cost\ customer\ service}}{\mathbf{hour}}$$

Cost classification: transaction: bargaining: administrative subscription
Cost actor: NP_1

7. Installation of the ONT by the new network provider (NP_2)

Once the administrative subscription is handled and the date of the ONT installation has arrived, a technician of NP_2 will travel to the end user's premise and installs a new ONT. This step is seen as necessary because different NPs might use different or non-compatible technologies. As a result, a new ONT is needed to comply with the technical specifications of the new NP. In order to install the ONT, three distinctive conditions must be fulfilled. The first condition is the transportation to the end user. Here, a technician will visit the end user's premises. The cost for this visit corresponds to one truck roll and is determined by the round trip time to the end user. The second condition that must be fulfilled is the purchase of a new ONT. Since the new ONT is NP-specific, the technician will mostly likely bring this ONT with him. However, the cost for this ONT will be assigned to the end user. This assignment can happen in two ways. Either the end user will pay a fixed price to cover the whole price of the ONT (used in this work) or the end user will rent the equipment from the NP and pay a renting fee every month. The third aspect of the installation is the physical installation of the ONT. Here, the technician will connect the ONT to the distribution fiber and connect it to the present RGW. The total cost for the installation of the ONT can be calculated as the sum of the different aspects. The purchase cost of the ONT and the ONT installation are seen as fixed cost. The cost for the truck roll, on the other hand, will depend on the distance that the technician has to cover. A larger distance results in a long round trip time and thus a higher cost. However, modeling this for every single end user is difficult and an average round trip time is chosen.

$$\begin{aligned}\textbf{Cost} = {} & \textbf{fixed cost average truck roll to end user } (\mathbf{1}) \\ & + \textbf{fixed cost for the ONT purchase } (\mathbf{2}) \\ & + \textbf{fixed cost for the installation of the ONT } (\mathbf{3})\end{aligned}$$

Cost classification: (1) Processes: Supportive processes
(2) Equipment: Working Equipment
(3) Processes: Operational processes
Cost actor: (1) and (3): New NP (NP_2)
(2): End user

8. The physical reconnection of the optical fiber

In a first phase, the alternative NP, NP_2 will notify the PIP about the physical reconnection of the fiber. The reconnection of this fiber depends on the network topology and is performed either in the CO or in the street cabinet closest to the end user. The notification must contain specifics on the physical reconnection that must occur. This will include a customer ID, a customer address, etc. The cost for this notification can be seen as the time spent on creating this notification times the cost per hour for the person creating the notification.

$$\textbf{Cost} = \textbf{time of a provider\_provider notification x } \frac{\textbf{labor cost customer service}}{\textbf{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: NP_2

The second phase of the physical reconnection of the optical fiber is performed by a technician of the PIP and will depend on the used topology.

a) <u>P2P topology</u>

Within a P2P topology, all end users have a dedicated fiber that runs from the CO to the end user's premise. From chapter 3.2.1 we recall that the connection of the fiber is made at the installed patch panel in the CO. In order to facilitate this reconnection at the patch panel, the PIP must send out a technician to the CO. Once the technician arrives at the CO, he will move towards the patch panel and locate the fiber that needs to be reconnected. This fiber is than cut and spliced towards a new ODF slot of the alternative NP. A final aspect of the reconnection in a P2P topology is the provisioning of this new ODF slot in the patch panel. The ODF slot will facilitate the connection towards the OLT of the alternative NP. The cost for the reconnection of an end users fiber consists of three fixed parts. A first part is the transportation to the CO. As the CO is in a fixed location, the round trip time to the CO will be always the same. The second part is the equipment cost of an additional ODF slot, which is fixed as well. The final part is the patching cost. Patching a fiber is a repetitive process. As such, the time spent on the patch, the equipment and the operator performing the patch will most likely be the same. Therefore, a single fixed cost can be used for the patching of a single fiber.

$$\mathbf{Cost = fixed\ cost\ \ truck\ roll\ to\ CO\ (1) + fixed\ cost\ for\ the\ ODF\ slot\ (2) + \ fixed\ cost\ for\ a\ fiber\ patch\ (3)}$$

Cost classification: (1) Processes: Supportive processes
(2) Equipment: Supportive Equipment
(3) Processes: Operational processes
Cost actor: PIP

b) P2MP topology

Within a P2MP topology, end users share a feeder fiber from the CO to the splitter in the street cabinet. From the street cabinet onwards, a distribution fiber runs to the premise. From chapter 3.2.1 we recall that in an open access scenario the distribution fiber should be connected to the right NP-specific splitter. As the NP-specific splitters are already present in the street cabinets, no additional equipment is needed. The cost for the reconnection of an end user's fiber consists of two fixed parts. The first part is the transportation to the street cabinet. Since the street cabinets are spread out over the entire geographical area, an average round trip time to the street cabinet will be used. The second part is the patching cost. Patching a fiber is a repetitive process. As such, the time spent on each patch will most likely be the same. Therefore, a single fixed cost can be used for the patching of a single fiber.

$$\textbf{Cost} = \textbf{fixed cost truck roll to CO } (1) + \textbf{fixed cost for the ODF slot } (2) + \textbf{fixed cost for a fiber patch } (3)$$

Cost classification: (1) Processes: Supportive processes
(2) Processes: Operational processes
Cost actor: PIP

After the physical reconnection of the fiber occurred, the PIP will notify the new NP (NP_2) that the connection has been made. The cost for this notification is classified as a communication cost under search and information. The cost for this notification can be seen as the time spent on creating this notification times the cost per hour for the person creating the notification.

$$\textbf{Cost} = \textbf{time for a provider\_provider notification x } \frac{\textbf{labor cost customer service}}{\textbf{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: PIP

9. The logical connection of the end user to the new NP

Once the new NP (NP_2) has received the notification that the new end user is physically connected, the NP has to logically connect the new end user. The NP will make a software connection as to connect an end user’s ONT to the corresponding OLT in the CO. From this point onward, the OLT will transmit signals through the network towards the end user’s ONT. After the software configuration, the network operator will perform a test to see if the connection works properly. The cost for this step will be calculated as the time spent on making the logical connection times the unit labor cost of a network operator.

$$\textbf{Cost} = \textbf{time spent on logical connection x } \frac{\textbf{labor cost network operator}}{\textbf{hour}}$$

Cost classification: Processes: Operational processes
Cost actor: New NP (NP_2)

10. The new network provider will notify the end user.

After a successful logical connect, the network provider will notify the end user that the process is completed and that the service provisioned by the network provider can be used. This notification can occur in the form of an e-mail or a letter. The cost is calculated as the time for a customer service employee to generate the notification, look up the corresponding address of the end user, and transmit the notification times the unit labor cost of a customer service employee. Since this process can be automated, it will be considered as one of the optimization in Chapter 6.

$$\mathbf{Cost = time\ for\ a\ end\ user\_provider\ notification\ x\ \frac{labor\ cost\ customer\ service}{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: New NP (NP_2)

Figure 20 will summarize the complete churn procedure within a cost matrix, showing the classification and assignment of the cost within each step.

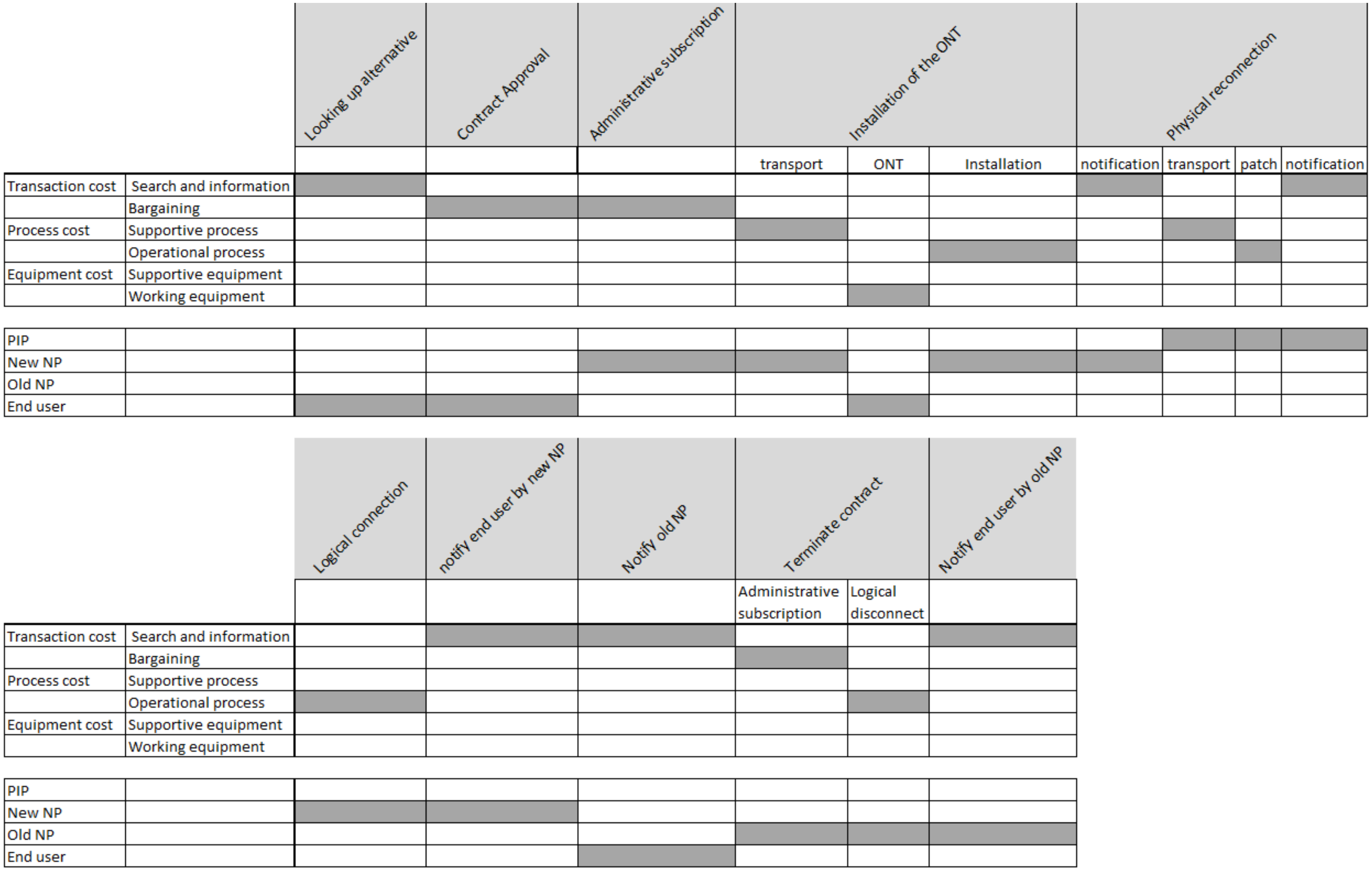

Figure 20: Cost matrix for an end user churning between network providers

4.2.2 Churn process for an end user switching to a new service provider

Within the next section, the churn process for switching to a new service provider is described. This process occurs within bitstream open access. Within the description of the procedure, sequential and successive steps are listed and completing all steps will result in the successful completion of a churn process. For each step in the procedure, a detailed description is given alongside the determining cost factors. When an end user churns service providers, a differentiation can be made between an end user installation and a service provider installation. This distinction is made as the installation of an RGW is assumed to be simple and is well documented. If this is the case, an end user should be capable to do this installation himself. Figure 21 shows the changes to the network that occur during the churn procedure for a SP installation. Furthermore, Figure 22 visualizes the BPMN flow chart of an end user churning service providers and gives an overview of this procedure.

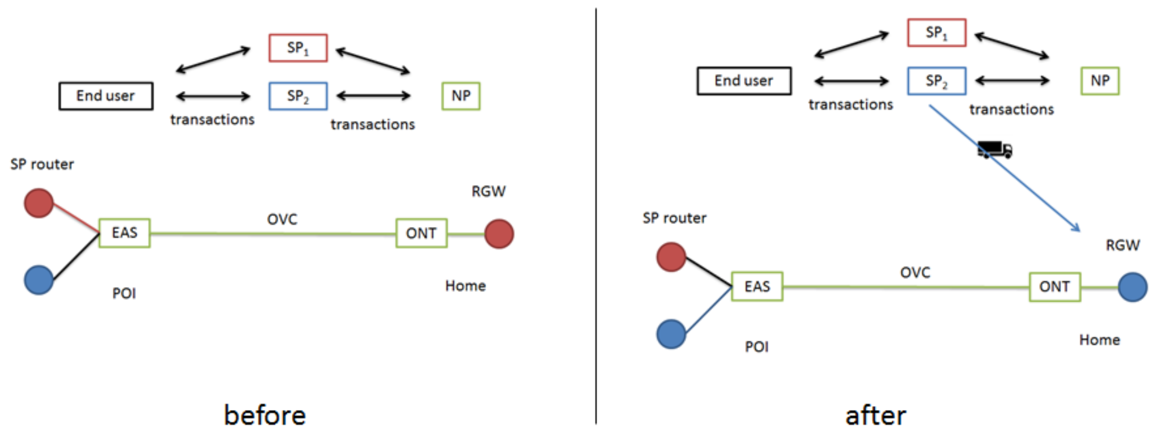

Figure 21: Network figure for an end user switching service provider

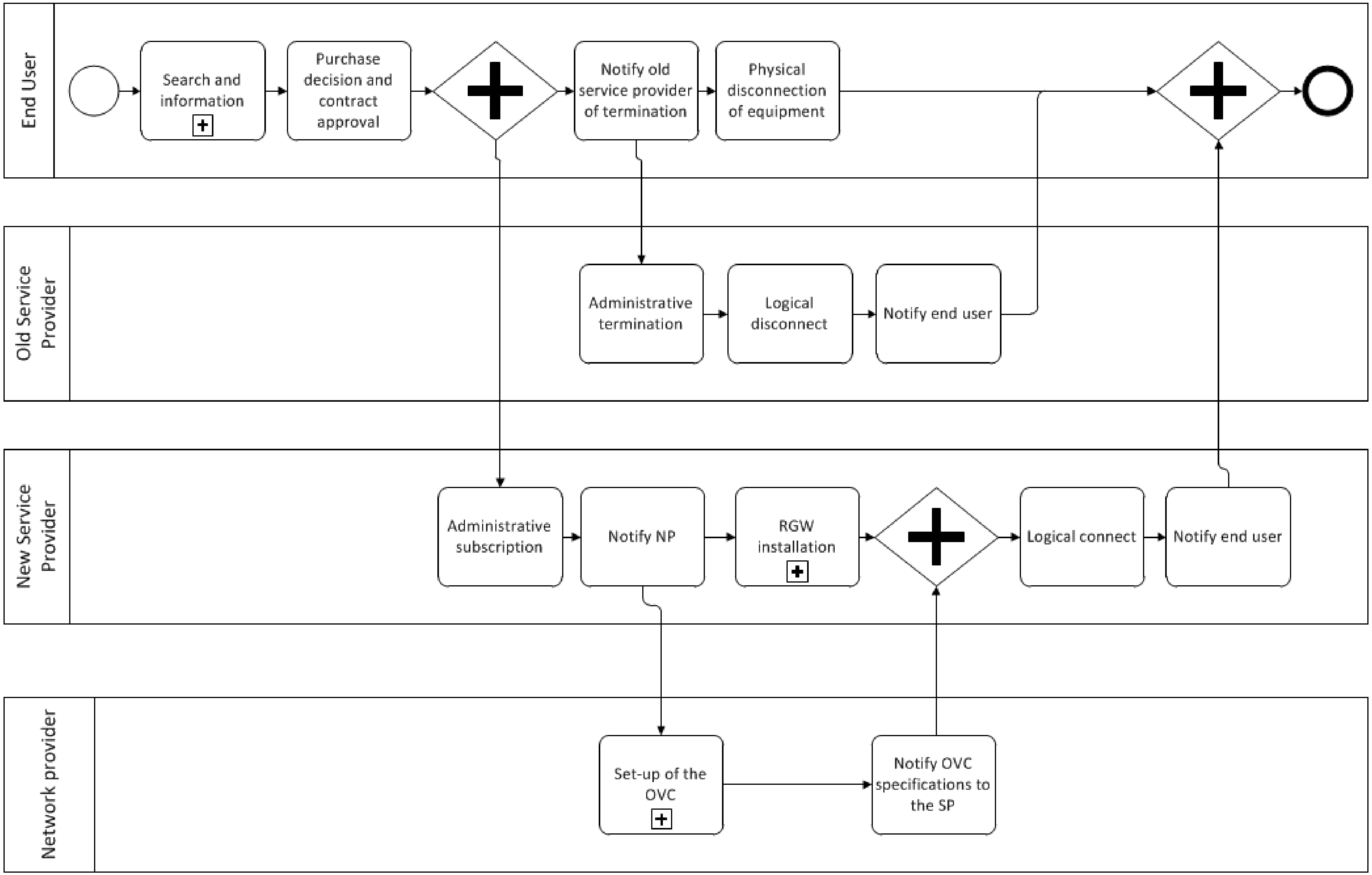

Figure 22: BPMN flowchart for an end user churning between service providers

Detailed description for an end user switching service provider

1. The end user wants to churn and will look for alternative offers.

This step is similar when an end user is churning service providers or network providers.

$$\textbf{Cost} = (\textbf{time spent on search for alternatives} + \textbf{time spent on comparing offers}) \textbf{ x } \frac{\textbf{labor cost end user}}{\textbf{hour}}$$

Cost classification: transaction: search and information
Cost actor: End user

2. Purchase decision by the end user and contract approval with the service provider

Once all alternatives are compared to each other, the end user will decide which offer he will purchase. After the decision is made, the end user will contact the provider and order the wanted service. As the end user does not have much bargaining power, he can only agree on the terms stated by the SP. This step is the same as for an end user churning network providers.

$$\textbf{Cost} = \textbf{time spent on contract approval x } \frac{\textbf{labor cost end user}}{\textbf{hour}}$$

Cost classification: transaction: bargaining: contract approval
Cost actor: End user

3. The notification of the termination of the current contract

Once the contract is signed with the new SP (SP_2), the end user will have to terminate the contract with the current service provider (SP_1). This can be done by notifying SP_1 with a written letter, filling in a digital form on the service provider's homepage, etc. This step is analogue to the case of an end user churning between network providers.

Next to the notification, the end user will physically disconnect the equipment. Since the disconnection of the equipment can occur fast and easily, the end user is capable of performing this step on his own. If the end user rented equipment (Appendix B: Interview, the end user must return the equipment to the SP.

$$\textbf{Cost} = (\textbf{time for an end user\_provider notification} + \textbf{time for physical disconnect}) \textbf{ x } \frac{\textbf{labor cost end user}}{\textbf{hour}}$$

Cost classification: transaction: search and information: communication
Processes: operational processes
Cost actor: End user

4. The termination of the current contract by the original service provider

If the service provider is timely notified, SP_1 will terminate the contract. The termination of the contract will consist of two parts. The first part will be the administratively termination of the end user's contract. Within this step, the SP will assign a final cost, distribute the final bill, and check if all bills have been paid. The assignment of the final cost corresponds to the assignment of a contract termination fee and penalty fees. Next to the assignment of final costs, SP_1 will distribute a final bill. A final aspect of the administrative termination is the payment checking. The SP will check if all bills have been paid. If the payment is late, the SP will send reminders or eventually undertake legal actions.

The second part of the termination of the contract consists of the logical disconnection of the end user. Here, the SP will perform a software operation and exclude the end user from the operational system, which in turn results in not receiving any service. The cost for the logical disconnection equals the product of the time needed for setting up a logical connection times a corrective factor and the unit labor cost of a network operator. The corrective factor corresponds to the fact that a logical disconnection is similar to a logical connection except that no testing is required.

$$\begin{aligned}&\mathbf{Cost}\\&= \mathbf{time\ of\ administrative\ termination\ x}\ \frac{\mathbf{labor\ cost\ customer\ service}}{\mathbf{hour}}\ (\mathbf{1})\\&+ (\mathbf{time\ of\ logical\ connection\ x\ correction})\ \mathbf{x}\ \frac{\mathbf{labor\ cost\ network\ operator}}{\mathbf{hour}}\ (\mathbf{2})\end{aligned}$$

Cost classification: (1) Transaction: Bargaining: Administration
(2) Processes: Operational processes
Cost actor: Original SP (SP_1)

5. The original service provider will notify the end user that the contract is terminated

After the administrative termination and the logical disconnect, the original service provider will notify the end user that the contract is terminated. The service provider can already include additional details within this notification. For example, if the end user has not returned his (rented) RGW, a first reminder can be included within the acknowledgement of the termination of the contract. The cost for this notification is determined as the product of the time spent generating this notification and the unit labor cost of a customer service employee.

$$\mathbf{Cost} = \mathbf{time\ off\ end\ user - provider\ notification\ x}\ \frac{\mathbf{labor\ cost\ customer\ service}}{\mathbf{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: Original SP (SP_1)

6. The administrative subscription of the end user by the new SP (SP_2)

This administrative step is similar to the one described for an end user switching network providers. The difference lies with the fact that responsible actor is now a service provider (for a more detailed description see step 4 of section 4.2.1).

$$\mathbf{Cost = time\ spent\ on\ administrative\ subscription\ x\ \frac{labor\ cost\ customer\ service}{hour}}$$

Cost classification: transaction: bargaining: administrative subscription
Cost actor: SP_2

7. Set up of the OVC

The set-up of the OVC consists of three distinctive parts. Within the first part, the new SP, SP_2 will request a new OVC from the NP. During the second part, the NP will set up a new OVC. The final part consists of the NP notifying the SP that the OVC is set up.

In a first phase, the alternative SP, SP_2 will have to order a new OVC from the connected NP. The SP will search the end user's database record for the connected NP. The SP will then send a request to the NP for a new OVC. This request will include a customer ID, name and address as well as the service that will be delivered. Furthermore, the SP will specify the committed information rate (CIR) that is needed to serve the end user on a normal basis.

$$\mathbf{Cost = time\ for\ a\ provider\_provider\ notification\ x\ \frac{labor\ cost\ customer\ service}{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: SP_2

Within the second phase, the NP will set up the OVC. This set-up consists of multiple parts. First, the NP will add the service to the end user's database record. The NP will then provide the end-to-end network configuration and configure the wanted service profile. As a final step, the configuration is thoroughly tested.

$$\mathbf{Cost = time\ for\ OVC\ set\ up\ x\ \frac{labor\ cost\ network\ operator}{hour}}$$

Cost classification: Processes: operational processes
Cost actor: NP

After the configuration of the OVC, the NP will notify the new SP (SP_2) that the OVC is ready. Furthermore, the NP will include the OVC specifications, which corresponds to the S- and C-tag that are associated with the VLAN.

$$\mathbf{Cost = time\ for\ a\ provider\_provider\ notification\ x\ \frac{labor\ cost\ customer\ service}{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: NP

8. Installation of the RGW

Once the administrative subscription is handled, the new RGW will be installed. An example of the need for a new RGW is given by the fact that service providers might use different technologies. This installation can be done in two distinctive ways. The first possibility is given by an SP installation. In order for SP_2 to install the RGW, three conditions must be fulfilled. The first condition is the transportation to the end user. Here, a technician will visit the end user's premises. The cost for this visit corresponds to one truck roll and is determined as the round trip time to the end user. The second condition that must be fulfilled is the purchase of a new RGW. Since the new RGW is SP-specific, the technician will mostly likely bring this RGW with him. However, the cost for this RGW will be assigned to the end user. The third aspect of the installation is the physical installation of the RGW.

$$\begin{aligned}\mathbf{Cost} = {} & \mathbf{fixed\ cost\ average\ \ truck\ roll\ to\ end\ user\ (1)} \\ & + \mathbf{fixed\ cost\ for\ the\ RGW\ purchase\ (2)} \\ & + \ \mathbf{cost\ for\ the\ installation\ of\ the\ RGW\ (3)}\end{aligned}$$

Cost classification: (1) Processes: Supportive processes
(2) Equipment: Working Equipment
(3) Processes: Operational processes
Cost actor: (1) and (3): New SP (SP_2)
(2): End user

The second possibility for the RGW installation is by the end user himself as the installation of an RGW is well documented and easy. The installation will simply compare to a "plug and play" situation. In this case, no transportation of a technician is needed and the cost for installation will be very low to negligible. However, the RGW must still be purchased

$$\mathbf{Cost} = \mathbf{fixed\ cost\ for\ the\ RGW\ purchase}$$

Cost classification: (2) Equipment: Working Equipment
Cost actor: End user

9. Logical connection of the end user

Once the new SP (SP_2) has received the notification with the OVC specifications, the SP has to logically connect the new end user. The SP will make a software connection so that the service is delivered through the OVC. After the software configuration, the service operator will perform a test to see if the connection works properly. The cost for this step will be calculated as the time spent on making the logical connection times the unit labor cost of a network operator.

$$\mathbf{Cost} = \mathbf{time\ spent\ on\ logical\ connection\ x}\ \frac{\mathbf{labor\ cost\ network\ operator}}{\mathbf{hour}}$$

Cost classification: Processes: Operational processes
Cost actor: New SP (SP_2)

10. The new service provider will notify the end user

After making a successful logical connection, the service provider will notify the end user that the process is completed and that the service will be provisioned. The cost is calculated as the time for a customer service employee to generate the notification, look up the corresponding address of the end user, and transmit the notification times the unit labor cost of a customer service employee.

$$\mathbf{Cost} = \mathbf{time\ for\ an\ \ end\ user\_provider\ notification\ x}\ \frac{\mathbf{labor\ cost\ customer\ service}}{\mathbf{hour}}$$

Cost classification: transaction: search and information: communication
Cost actor: New SP (SP_2)

Figure 23 summarizes the complete churn procedure within a cost matrix. Within this matrix, the different steps are listed alongside the cost classification and the responsible actors.

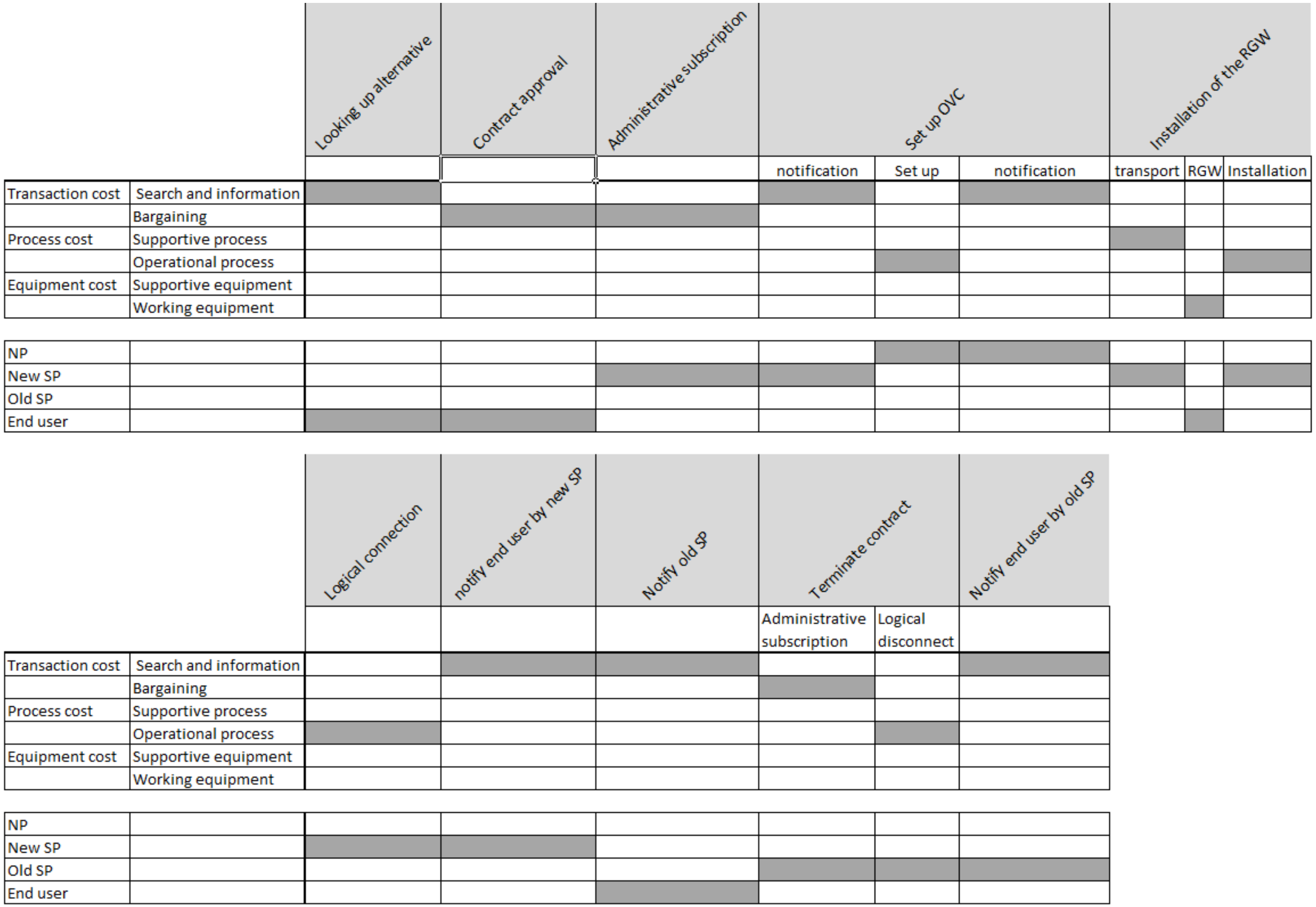

Figure 23: Cost matrix for an end user switching between service providers

4.3 Conclusion

Within this chapter, the classification and identification of cost drivers for churn was studied. The classification of the costs is based on a defined tree structure, where the branches correspond to the different nature of the churn costs. There are costs related to equipment, processes, and transactions. After the cost categorization, the different churn procedures were described. These procedures were an end user switching network provider and an end user switching service provider. In case of an end user churning network providers, a distinction was made between churn over a P2P topology and churn over a P2MP topology. In case of an end user switching between service providers, a difference between an end user and a SP installation was taken into account.

The description of the different churn procedures was based on the listing of all sequential steps. For each step, a detailed description, a calculation method for the costs and a cost classification is given. The description of the different procedures is summarized with the visual representation of the churn procedure through a BPMN flow chart and a cost matrix, showing the assignment of the present costs to both the responsible actors and the cost categories from the cost breakdown structure.

Chapter 5 Implementation of the churn model and analysis of the results

Within this chapter, the modeling and the analysis of the cost for churn is described. The first part will cover the definition and implementation of the model. Within the model, the cost for churn is calculated based on the different churn procedures. Furthermore, every procedure relies on specific input values and a set of specified cost functions as defined in the previous chapter. The section about the model will be concluded with a unified modeling language (UML) class diagram that corresponds to the java implementation of the model. The second part of this chapter will cover the different input values necessary to generate the cost for churn. Within the third part of this chapter, the cost for the churn of a single end user will be examined. This examination will cover churn within bitstream and fiber open access. For each churn procedure, a cost assignment will be made towards both actors and cost categories as defined in the cost breakdown structure. Next, the found results will be compared to values found in literature. The final part of this chapter will compare the cost for churn with other key metrics within the telecommunications sector.

5.1 Definition of a model for the investigation of churn

In order to investigate the impact of churn, the different churn procedures must be modeled. The modeling of the churn cost is based on the cost divers as identified in Chapter 4. For each of the different types of churn, the model will generate a cost for the churn procedure as shown in Figure 24. Once the requested churn procedure is entered in the model, the model will retrieve the suitable input values for that specific churn procedure. The model will then supply these input values to a calculator module. This calculator module in turn calculates the cost for every sub-step within the procedure based on the supplied input values and the corresponding cost function for each sub-step. After the calculation of all sub-steps, the cost for the specific churn procedure is returned to the model. The model will then process the cost of churn in two different ways. Either the generated costs for churn are assigned to the different cost categories as defined in the cost breakdown structure, or the costs are assigned to the responsible actors.

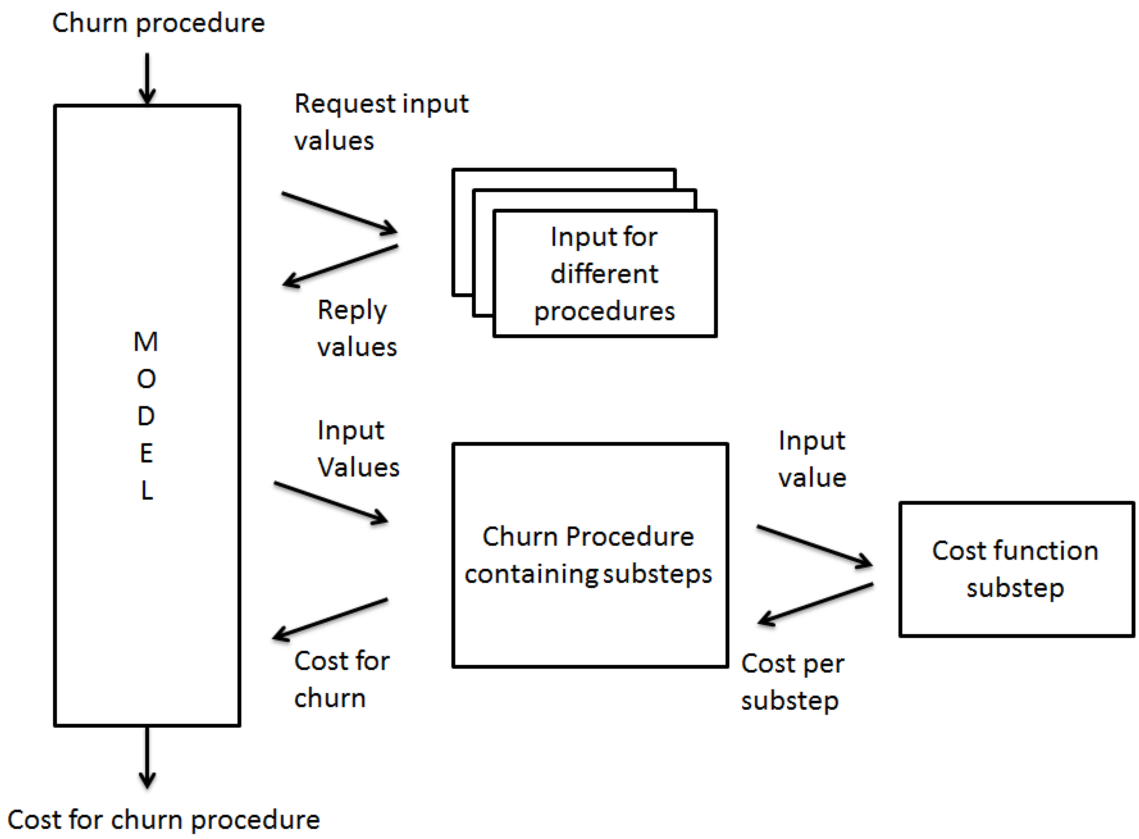

Figure 24: Representation of the model

The model for the calculation of the costs related to the different churn procedures is implemented in a java-environment. Within this implementation, the costs for churn are kept within a Hash table [54]. This Hash table consists of a key and value pair, where the key is the type of churn costs as defined within the cost breakdown structure, and the value equals the cost over multiple years.

Figure 25 represent the class diagram for the implementation and structure of the model. This class diagram is made within UML (Unified Modeling Language), which is a used standard, defined by the object management group [55]. It shows how the different classes, their attributes, and methods are interlinked to each other and specifies these relations. Within the diagram, each class is represented by one block and each block consists of three parts. The top part contains the name of the class; the middle part of the block contains all the defined attributes while the bottom part contains the executable methods of the class.

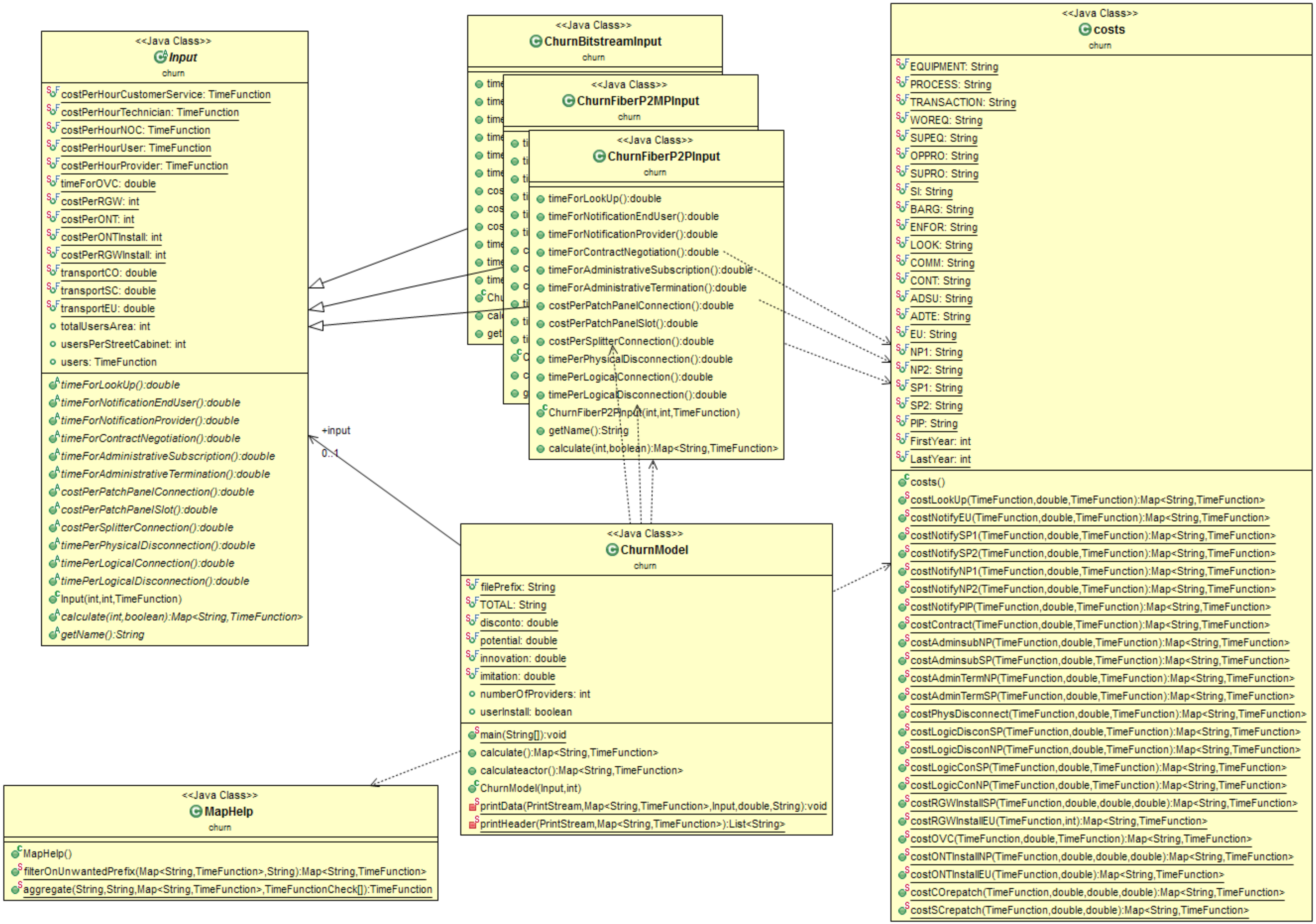

Figure 25: UML Class diagram

5.2 Definition of the input values as used by the model

An important aspect of achieving quantitative results for the process of churn, both for bitstream and fiber open access, are the input values used during the calculations. These input values are shown in Table 2. The cost drivers within this table are grouped by their determining factor. The first group relates to equipment and has a fixed cost. For example, the cost of an ONT is fixed at a value of € 50. The second group of cost drivers contains the different labor costs for each actor and determines the cost associated with a person performing a single job. Here, the cost per hour for end users is chosen to be zero since the end user performs all actions within his free time. However, this will result in some "hidden" costs for the end user. In order to investigate these costs, a variation on the labor cost for an end user will be performed. The third group contains the duration of processes. By multiplying the duration of a process with the cost per hour of the person that performs the job, the cost of a process can be achieved. The final group of costs considers transportation costs. This cost is determined as a fixed cost that reflects the round trip time needed to perform the transportation.

Table 2: Input values used within the model

Cost driver	Cost	Source
Equipment related costs		
Cost of an ONT	€ 50	[33]
Cost of an RGW	€ 50	[44]
Cost of ONT install	€ 30	[56]
Cost of RGW install	€ 30	Assumption, similar to the installation of an ONT
Cost per patch panel slot	€ 20	[16]
Connection at patch panel	€ 13	[56]
Connection at splitter	€ 10,5	[56]
Labor costs		
Cost per hour customer service	€ 45	[56]
Cost per hour technician	€ 52	[56]
Cost per hour network operator	€ 58	[56]
Cost per hour end user	€ 0	End user performs the action in his free time, alternatively an opportunity cost can be assigned
Time		
Looking up	1,25 hours	[57] and [58]
Notification Provider-Provider	0,2 hour	Assumption: Providers work with a limited amount of other providers. As a result, the information exchange with other providers is already standardized

Notification Provider-End user	0,5 hour	[59] notify customer
Contract negotiation and approval	0,25 hour	Assumption (End user has little to no bargaining power)
Administrative subscription	1,7 hours	[59] contract handling + assign cost + distribute bill
Administrative termination	1,7 hours	[59] assign final cost + distribute bill + check payment
Set up OVC connection	1,3 hours	[16] service profile configuration + add service to database + end-to-end network configuration + test
Physical disconnection	0,1 hour	Assumption: very short , corresponds to unplugging cables
Logical connection	0,5 hour	[59] plan, install, configure local domain, test
Logical disconnection	0,375 hour	Assumption: time of logical connection ([59]) times 0.75 as no testing is needed.
Transport		
Transport to the Central Office	€ 14	[44], [60]
Transport to the Street Cabinet	€ 28	[44]
Transport to the End user	€ 36	[44]

5.3 Churn within bitstream open access

The first churn procedure that is investigated is the churn of an end user within bitstream open access. Here, the end user will switch from one service provider to another. The cost for this procedure is calculated as the sum of all sub-steps. Furthermore, the cost of each sub-step is calculated by the combining the identified cost drivers from section 4.2.2 and the input values from section 5.2. For example, the cost for the administrative termination and the logical disconnection of an end user by the old service provider is calculated by the formula below. The suitable input values are retrieved from Table 2.

$$\mathbf{Cost} = \mathbf{time\ of\ administrative\ termination\ x}\ \frac{\mathbf{labor\ cost\ customer\ service}}{\mathbf{hour}} \quad (1)$$

$$+\ \mathbf{time\ of\ logical\ disconnection\ \ x}\ \frac{\mathbf{labor\ cost\ network\ operator}}{\mathbf{hour}} \quad (2)$$

The time spent for administrative termination is 1.7 hours while the time for the logical disconnection equals the time of a logical connection times a corrective factor or 0.5 * 0.75. Furthermore, the labor cost for the customer service is € 45 per hour while the labor cost for a network operator is € 58. Substituting these values in the cost formula resulted in a total cost of about € 98.25 for this step. Since all actions are performed by the old network provider (NP_1), this cost will be assigned to NP_1.

Allocation of the churn costs to the different cost categories

The total cost for an end user churning service providers is about € 420 and consists of the different costs as shown in Figure 26. The incurred costs are mainly determined by the process and transaction costs. The process costs take up about € 190 which corresponds to about 45 %. The process costs can be further split up into operational and supportive processes. Within the process costs, the majority is determined by the operational processes which take up about 36% of the total costs. These operational processes consist of the set-up of the OVC, the logical disconnection with the original SP (SP_1), the logical connection with the new SP (SP_2), the installation of the RGW by the new SP, and the physical disconnection of the original equipment by the end user. The minority of the process costs are the supportive processes. These supportive processes correspond to 8.5% of the total cost. The highest cost within the process costs is the set-up of an OVC and equals € 75.4 which corresponds to 40% of all process costs. This high cost is explained as the time spent for the creation of this OVC is 1.3 hours and the labor cost for the network operator is € 58.

Equally important to the process costs are the transaction costs that take up about 43% of the total costs and correspond to about € 180. These costs can be further split into bargaining costs (36 % of the total cost) and search and information (6.5% of the total cost). The bargaining cost can be further split into two equal parts that correspond to the administrative subscription and the administrative termination of a new end user. A high cost of € 76.5 is seen for both administrative procedures. This costs results from a duration of 1.7 hours and a labor cost of € 45 per hour to facilitate for one administrative subscription/termination process. The remaining transaction costs are search and information costs. These information costs consist of 3 equal shares containing the different notifications send out by the providers. Next to the process and transaction costs, the remainder of the total cost is filled up by the equipment cost. This cost corresponds to the purchase of a new RGW of € 50 and takes up about 12% of the total cost.

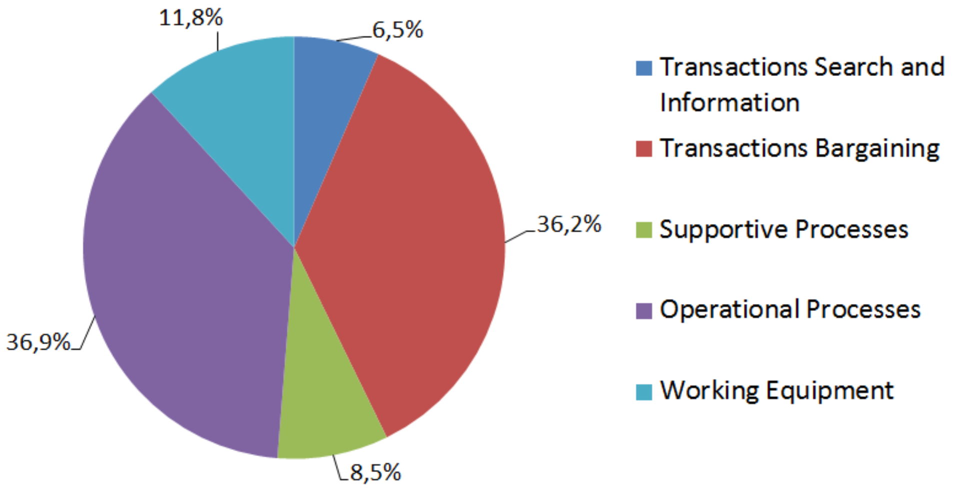

Figure 26: Cost distribution of the occurring costs within bitstream open access

Allocation of the churn costs to the different actors

The classification of the occurring churn costs within bitstream open access can also be split up by responsible actors. Figure 27 shows that the new SP (SP_2) is responsible for the majority of the costs. These costs will sum up to about € 180 out of € 420 which in turn corresponds to 43 % of the total costs. Of the incurred costs by SP_2, a little more than half is assigned to processes. The process costs contain the logical connection of the end user, the transportation towards the end user, and the installation of the new RGW at the end user's premises. On the other hand, the transaction costs contain the administrative subscription of the new end user and the notification of the end user that the service can be used. Here, the cost associated with the administrative subscription is the highest due to the long time spent on this administrative process.

The second largest part of the costs is attributed to the original SP, SP_1 and takes up about € 110 or 25% of the total cost. The costs incurred by SP_1 are twofold and consists of transaction and process costs. The Transaction cost consists of the administrative termination of the end user and the corresponding notification. The process cost, on the other hand, contains the costs for the logical disconnection of the end user from the SP's network.

A third part of the cost is assigned to the NP. This cost of € 85, which corresponds to 20% of the total cost, corresponds to set up of the OVC and the communication of the OVC specifications between the NP and the SP_2 for the delivery of the OVC. Even though the cost for communication is relatively low, the cost of about € 75 for the creation of the OVC will be the determining factor. This cost relates to both the time spent at creating this OVC (1.3 hours) and the hourly labor cost of a network operator (€ 58 per hour).

The final aspect of the costs is assigned to the end user. This expense corresponds to the purchase cost of a new RGW. This new RGW might be needed as the new SP might use a different technology than the original SP. However, next to the equipment cost for the end user, some transaction and process costs will be incurred. These transaction costs correspond to the look up of an alternative SP and the associated contract (negotiation and) approval costs. The values for these costs are not represented in Figure 27 as the cost per hour for an end user was set to € 0. However, setting this cost to a value of € 0 is not representative.

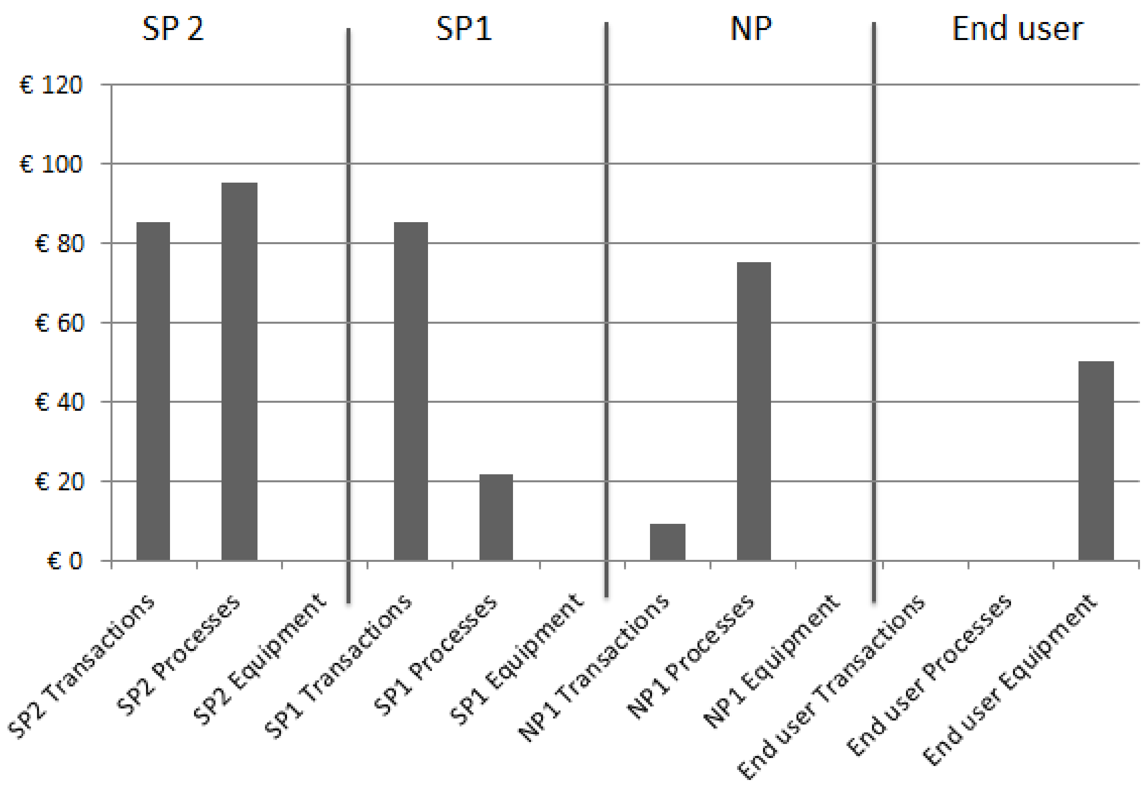

Figure 27: Cost distribution of churn within bitstream open access per responsible actor

Impact on the churn cost for the assignment of an opportunity cost to the end user

Within the previous section, the (labor) cost per hour for an end user was set as € 0. In order to achieve a thorough investigation of the costs associated to the end user, different opportunity costs are assigned and this for the case of the service provider performing the installation of the new RGW. Here, the opportunity cost is defined as the cost of the best possible alternative. This means that while the end user could be doing something else, he has to perform a number of specific actions (search for offers, compare offers, etc.) and therefore misses an opportunity. The result of this assignment is visible in Figure 28 and Figure 29. Within Figure 28, the different cost categories are listed for a variety of opportunity costs. Here, the cost per hour for an end user was chosen in a range from € 0 to € 25 per hour. As such, the total cost of churn procedure ranges from about € 420 to €460.

Furthermore, the assignment of a different opportunity costs has no effect on the working equipment and the supportive processes. This results from the fact that the cost for the working equipment (RGW) is a fixed cost and the transportation that is included within the supportive processes is performed by a technician and not by the end user. The increase in operational process costs is maximal €2. This change corresponds to a cost for the physical disconnection of equipment by the end user. This slight increase results from the fact that a physical disconnect is fast and will not take up much time. Since this increase only corresponds to 1% of the cost for operational processes, it is considered negligible. The true difference lies only within the transaction costs. First, assigning an opportunity cost increases the search and information costs to a total of about € 60. Hereby, the search and information costs are doubled when assigning an opportunity cost of € 25 to the end user. The increase is the result of an end user looking up different offers, comparing these to each other and then notifying the old provider of the termination of the contract. Second, the cost for contract approval is increased and ranges from €0 to about €7. However, on a total bargaining cost of about € 160 this will have a minor effect.

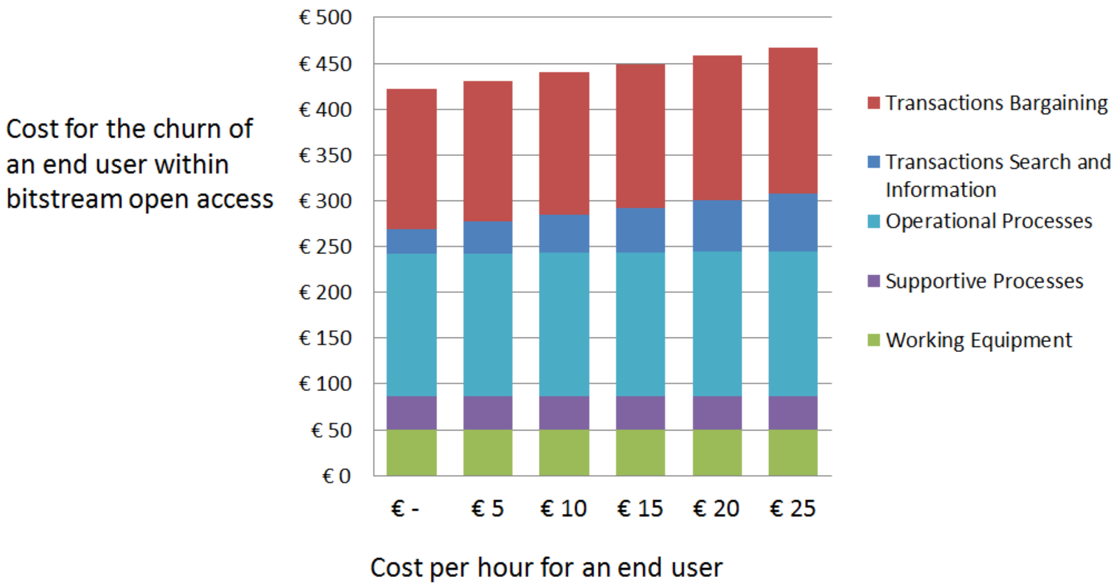

Figure 28: Effect of a difference in cost per hour for an end user on the different cost categories

Next, the effect on the different actors can be examined. As the opportunity cost is only applicable to the end user, the cost for the other involved actors, i.e. SP_1, SP_2, and the NP will remain the same. From Figure 29, we see that the equipment cost is still the largest and remains the same at € 50. This equals the purchase cost of the RGW and this cost is independent of the chosen opportunity cost. The transaction cost linearly increases with the opportunity cost and will reach a maximum of about € 42. Within the transaction costs assigned to the end user, the increase of the search and information costs will take up the majority since the end user spends a lot of time searching for new offers and comparing these to each other. The time spent at this step equals 1.25 hours of which one hour is spent at comparing the alternatives to each other and making a decision. Finally, even though the process costs increase as the opportunity cost increases, they will remain negligible compared to the other costs incurred by the end user.

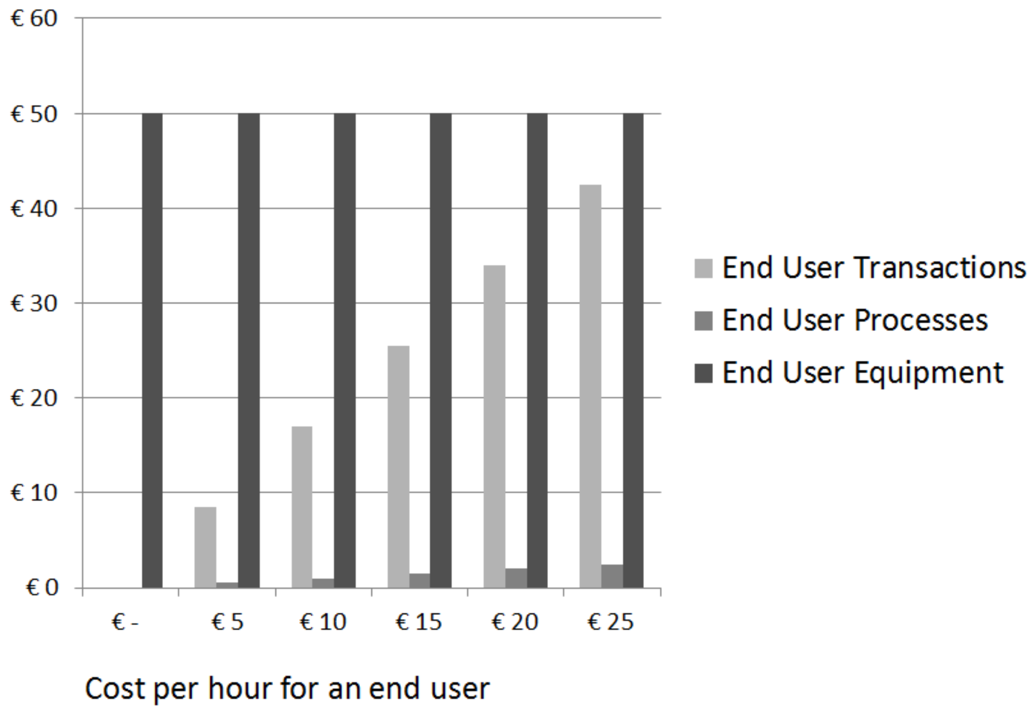

Figure 29: Effect of an opportunity cost on the end user costs within bitstream open access

Identification of the most important costs through Pareto analysis

After the investigation of the assignment of costs to the different cost categories and actors, the costs can be examined more in detail by the application of a Pareto analysis and the use of a Pareto chart. The Pareto chart contains both a bar and a line graph where the bar graph corresponds to the individual cost of each task. The line graph represents the cumulative total of all costs. Pareto charts can be used to highlight the most important costs factors. Using a Pareto chart, an investigation can be made towards the Pareto principle, otherwise known as the 80-20 rule. This principle states that for many events, about 80 % of the costs come from 20 % of the processes. It can be used as a decision rule that statistically separates a limited number of input factors as having the greatest impact on an outcome [61]. As the Pareto chart shows the highest costs, it can be used to identify the steps of the churn process that are the most susceptible to optimization. These costs will then be optimized in Chapter 6.

The Pareto chart for churn in bitstream open access, shown in Figure 30, indicates that the highest cost corresponds to that of administrative termination and administrative subscription. Both administrative costs take up about 20 % of the total cost and equal about

€ 76. The administrative procedures take 1.7 hours and are performed by a customer service employee. Even though both administrative processes costs are the same, their composition is completely different. Administrative subscription consists of contract handling, assigning a service cost to the end user, and the distribution of bills. Administrative termination, on the other hand, consists of the assignment of a final cost, the distribution of a final bill, and the checking if all payments have been performed.

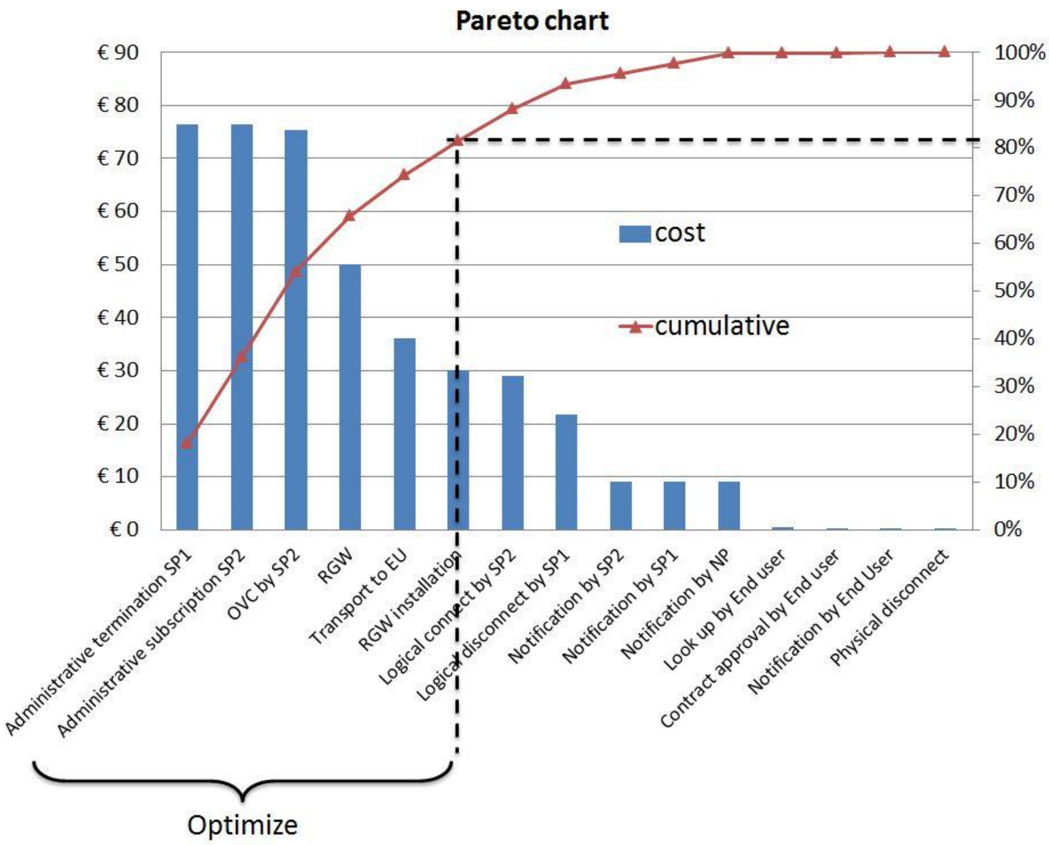

Figure 30: Pareto analysis of the costs incurred for bitstream open access

Comparison of the churn cost between an end user and a service provider installation

The previous examination of bitstream open access contains the scenario of the SP performing the RGW installation. However, when this process is well documented or easy to follow, an end user himself can perform this installation. When the end user performs the installation by himself, the overall cost for churn is reduced by about € 60, from € 420 to € 360. Figure 31 shows that this reduction can be attributed to cost savings in processes. The first part is a cost saving on operational processes. Here, the end user performs the RGW installation by himself and no technician is required to perform this action. Because no technician is needed, a cost savings can also be seen for supportive processes. This cost savings corresponds to the transportation to the end user. All other incurred costs remain the same. Because of the cost savings in operational and supportive processes, the overall process and transactions costs are not equally important anymore and the transaction costs become the most important costs. The transaction costs will correspond to € 180 which is about half of the total costs. The most determining factors remain the administrative subscription and termination. Because of the elimination of the two processes, the importance of process costs decreases to a total of about €125 which equals 35% of the total cost. In both cases, the equipment cost remains the same and is that of the purchase of a new RGW.

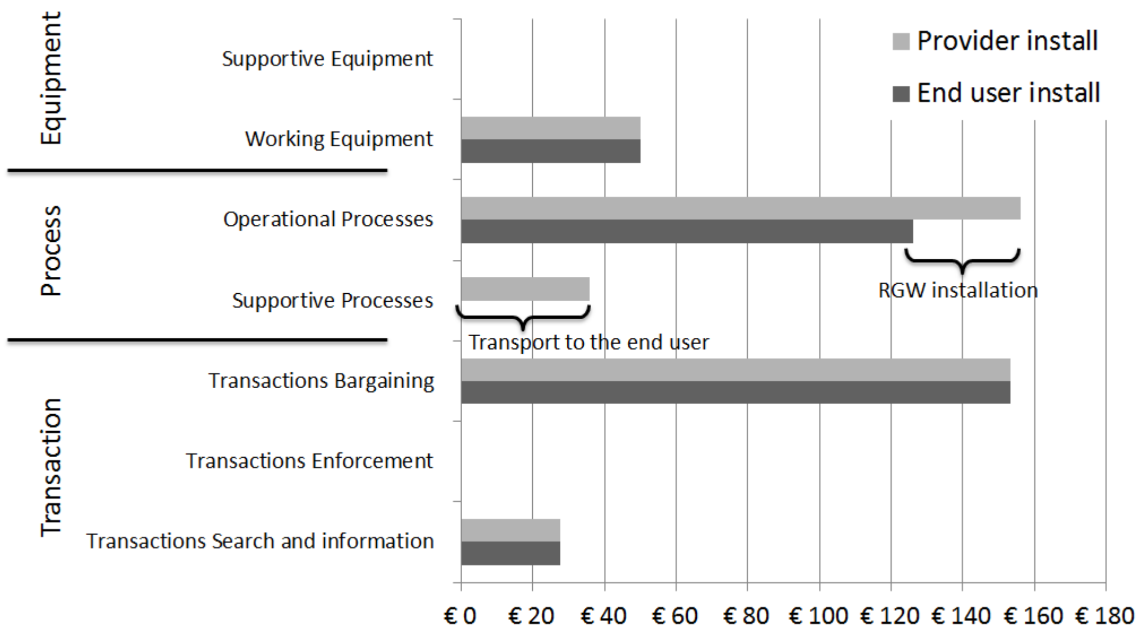

Figure 31: Comparison of the costs for churn in bitstream open access for a provider and an end user installation

Comparing the cost assignment per actor (Figure 32), both process savings are assigned to the new SP (SP_2). The costs assigned to the other involved actors, the original SP, the NP and the end user, will remain the same. Therefore, the end user installation will only be beneficial for the new SP. Because of the end user installation, the overall cost for the new SP will (SP_2) will decrease. Furthermore, where SP_2 previously held the majority of costs, both SPs now have a cost share of about 30% closely followed by the NP with about 25% of the costs.

Figure 32 shows the different in nature for the incurred cost between both SPs and the NP. Here, the cost for both SPs is mainly determined by transactions and a small share in processes. In case of the NP, this situation is mirrored. The majority of the NPs costs are assigned to processes. Investigation of the cost aspects shows why. Administrative subscription or termination is the highest cost present for a SP. This cost is classified as a transaction costs because is corresponds to the interaction between the end user and the service provider. On the other hand, the highest cost for the NP is the operational process for the set-up of the OVC.

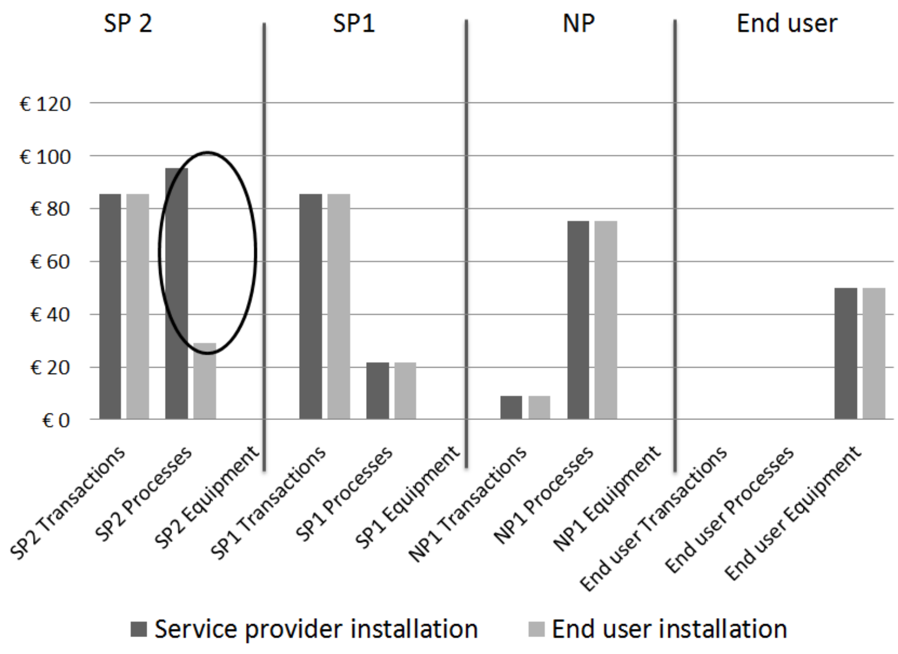

Figure 32: Cost assignment per actor for bitstream open access and an end user installation

5.4 Churn within fiber open access

After the examination of bitstream open access, an investigation of churn on fiber open access is made. Within fiber open access, a distinction can be made between a point-to-point (P2P) and a point-to-multipoint (P2MP) topology and the cost for churn corresponds to the cost for an end user switching between two network providers. The cost for churn within fiber open access is calculated similarly as the cost for churn within bitstream open access. The cost for churn is calculated by taking the sum of the costs for the different processes within the churn procedure. Furthermore, the cost of each sub-step is calculated by the combining the identified cost drivers from section 4.2.1 and the input values from section 5.2. For example, the cost for a notification between the NP and the PIP is calculated as the time needed to generate this notification times the cost for a customer service employee. Retrieving the suitable input values from Table 2 give 0.2 hour for the notification and € 45 for the labor cost per hour. This results in a notification cost of € 9.

$$\textbf{Cost} = \textbf{time of a provider\_provider notification x } \frac{\textbf{labor cost customer service}}{\textbf{hour}}$$

The summation of all sub-steps results in a cost for churn in a P2P topology of about € 395 while the cost for churn is slightly cheaper in a P2MP topology and costs about € 385.

Allocation of the churn costs within a P2P topology per cost category

In case of a P2P topology, the majority of costs are taken up by the transaction costs. These transaction costs are about € 180 and take up 45% of the total costs. Furthermore, these costs can be split in two subcategories: bargaining and search and information costs. Here bargaining takes up the majority of the transaction costs with € 150 or about 40% of the total costs. Next to the different bargaining costs, search and information costs will be present regarding the communication between the different actors involved in the churn of the end user. These communication costs take up 5% of the total cost of churn in a P2P topology. Since the labor cost per hour for an end user is set back to zero, the communication costs only takes into account the notifications sent by providers. Increasing the cost per hour for an end user gives similar results as within bitstream open access.

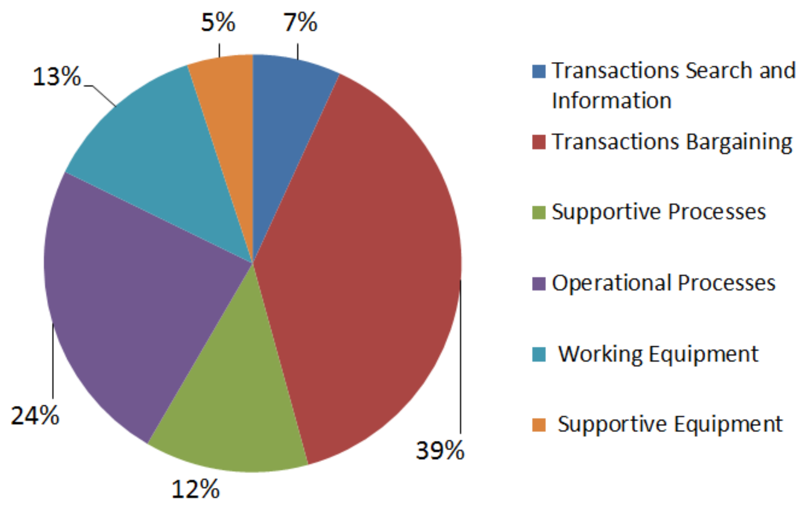

Figure 33: Cost allocation per category for a P2P topology

The second largest cost group for churn in a P2P topology is the process cost. The process cost will be about € 150 and equals a little less than 40 % of the total cost. The process costs within a P2P topology can be further differentiated into operational and supportive processes. The former takes up two thirds of the process costs while the latter consist of one third of the process costs.

The final and smallest group of costs for churn in a P2P topology is the equipment cost. This cost sums up to € 70, which equals a little less than 20% of the total cost. The equipment cost in itself is twofold. First, there is the working equipment cost of a new ONT. This new ONT is needed as different operators might operate with different technologies. This cost corresponds to the fixed cost of a new ONT, which is set at € 50. The second cost is that of a new patch panel slot that is needed to create the connection between the network side of the PIP and the new fiber of the NP at the system side of the patch panel.

Allocation of the churn costs within a P2MP topology per cost category

In case a P2MP topology is used, a total cost for churn of € 386 can be found alongside a different cost breakdown. Similar to a P2P topology, the transaction costs take up the majority of the costs, followed by the process and the equipment costs. The occurring transactions are the same to that of a P2P topology, an equal cost is found. As a result, the largest transaction cost remains the administrative subscription and administrative termination of the end user; both processes take up about 20% of the total cost.

The second largest group is the process costs. The process costs are about € 155 and correspond to about 40% of the total cost. Similar to a P2P topology, about two thirds of this cost corresponds to operational processes. These costs are, in order of decreasing significance: the installation of a new ONT at the end user's premises, the logical connection of the end user to the new NP; the logical disconnection of the end user from the old NP; the repatch of the fiber at the street cabinet to the right splitter; and the physical disconnection of the original ONT. Next to the operational processes are the supportive processes which, take up about one third of the process costs. These supportive processes are determined by two transportations. The first transportation is equal to the one of a P2P topology and corresponds to the travelling of a technician to the end user's premise. The second transportation is different however. Instead of the transport to the CO, it is a transport to a street cabinet. Since the transportation to the CO is cheaper, the overall supportive process cost is lower when compared to a P2P topology.

The third and final group of costs for churn in a P2MP topology is the equipment costs. This cost is €50 and corresponds to about 13% of the total cost. This cost is solely determined by the cost of the new ONT.

Comparison of the churn cost between an end user and a service provider installation

Churn can both happen on a P2P and a P2MP topology and therefore, one can compare both costs to each other (Figure 34). Comparing both topologies to each other, four equal cost categories can be found and alongside three different ones. The equal costs are three types of transaction costs and one equipment cost: bargaining costs, enforcement costs, which is zero, search and information costs, and working equipment. The equipment cost corresponds to the cost of an ONT, which is the same for both topologies. The transaction costs are the same as there is no difference between the acting parties. The administrative subscription and termination remains the same, as well as the different notifications that are sent between the involved parties.

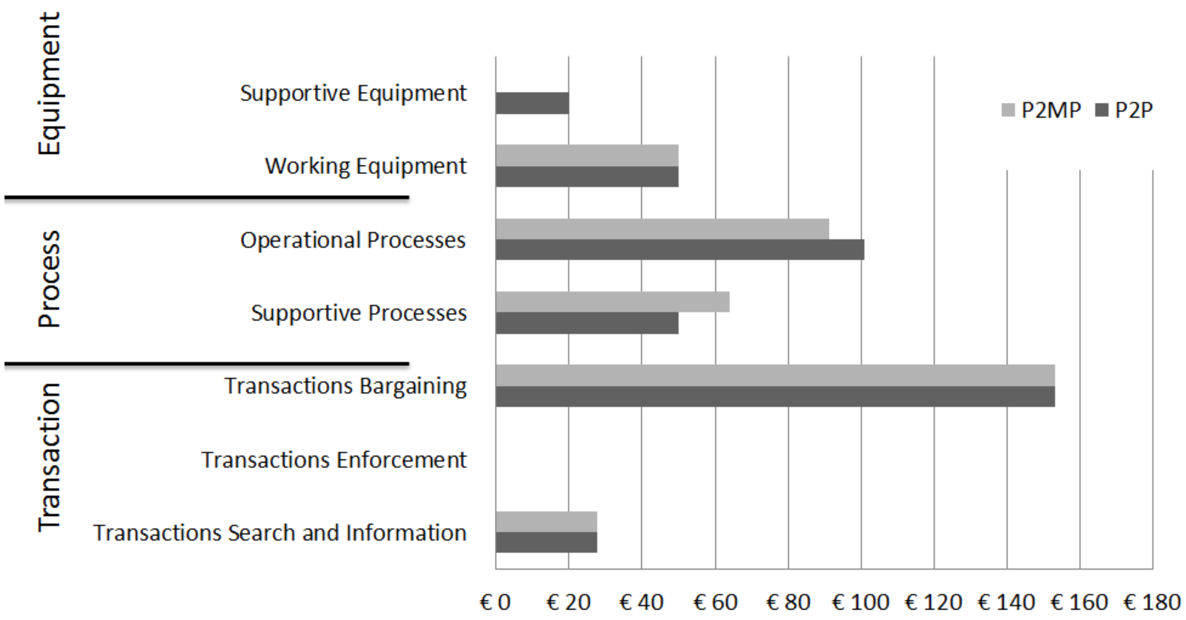

Figure 34: Cost categorization of the churn costs for both a P2P and a P2MP topology in fiber open access

A difference can be seen for both supportive and operation processes, as well as for supportive equipment. The difference in supportive processes is a result in the difference in transportation. Within a P2P topology, transportation is needed to the CO and the end user, while for a P2MP topology, transportation is needed to the street cabinet and the end user. The round trip to the end user remains the same, but the round trip to the street cabinet is longer. As a result, the supportive process costs will be more expensive in a P2MP topology. The second process difference can be found for operational processes. The processes here are the installation of the ONT, the logical connection and disconnection, the repatching of the fiber and the physical disconnection of the old ONT. The only difference between both topologies lies at the repatching of the fiber. As the repatching of a fiber in a P2MP topology is slightly easier than in a P2P topology (finding the right fiber at a splitter in a street cabinet versus finding a fiber in a patch panel for the entire geographical area), the cost will be a little cheaper. As a result, the operational process cost for a P2MP topology will be cheaper than that of a P2P topology.

The final difference can be found for the equipment cost and more specific for supportive equipment. Within a P2P topology, the technician must place an additional ODF slot at the patch panel. This slot has a cost of €20. In case of a P2MP topology, the technician does not have to place additional equipment at the street cabinet as the splitter is already present.

Allocation of the churn costs to the different actors

The next step in the investigation of the analysis of churn in fiber open access consists of the examination of the costs assigned to the different actors (Figure 35). For both topologies, the alternative NP (NP_2) is responsible for the majority of the costs. In both cases, this cost equals about € 180 which is about 45% of the total cost. This cost furthermore exists out of transaction and process costs where the cost of the latter is slightly higher than those of the transaction costs. The process costs consist of the installation of the new ONT, the transportation towards the end user's premises, and the logical connection of the new end user. The transaction costs are determined by the notification towards the end user that the end user is connected and the administrative subscription of the new end user.

The second largest costs are assigned to the original NP and are equal in both cases. The cost for the original NP equals about € 110 or 27 % of the total cost. In contrast to the costs for the new NP, a significant difference can be seen between the transaction and the process costs. The transaction costs are the largest and equal about €85. The majority of this cost corresponds to the administrative termination of the end user. The process costs, on the other hand only contain the cost for the logical disconnection of the end user.

The third highest cost is assigned to the physical provider and here a difference can be seen between a P2P and a P2MP topology. The PIP cost with a P2P topology equals about € 63 while this is about € 50 for a P2MP topology. Within a P2P topology, the largest part of the cost for the PIP is assigned to process costs, followed by and equipment cost and a transaction cost. Within a P2MP topology, the cost breakdown for the PIP is slightly different and does not contain any equipment costs.

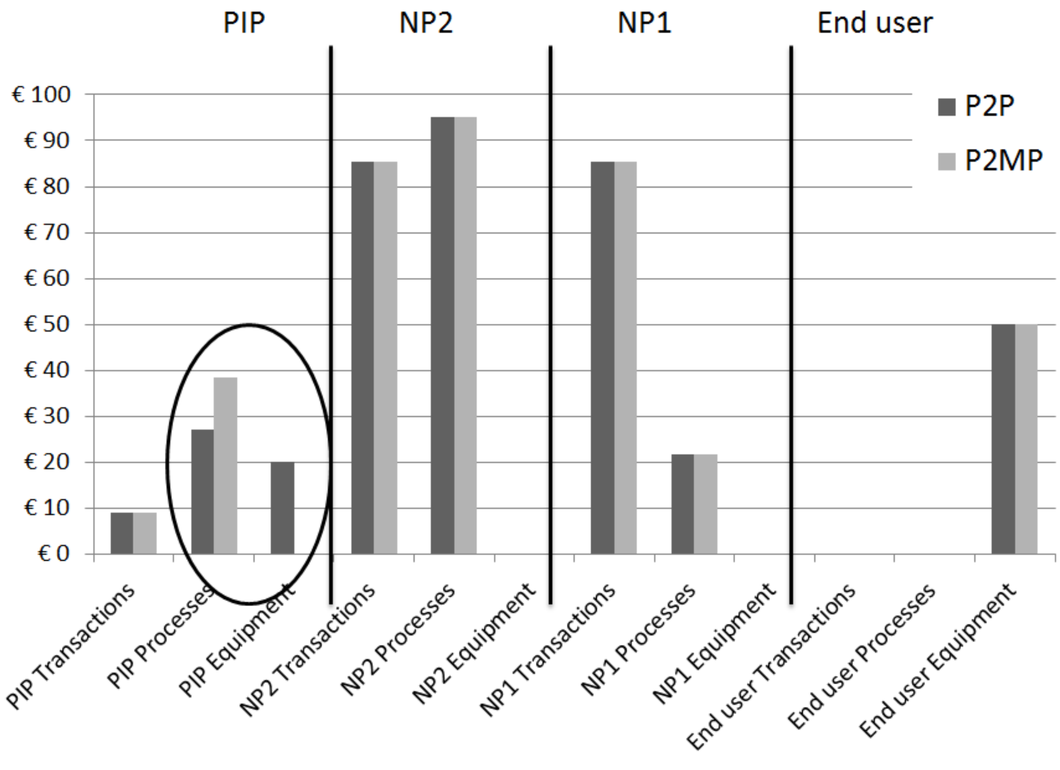

Figure 35: Cost assignment per actor in fiber open access for both a P2P and a P2MP topology

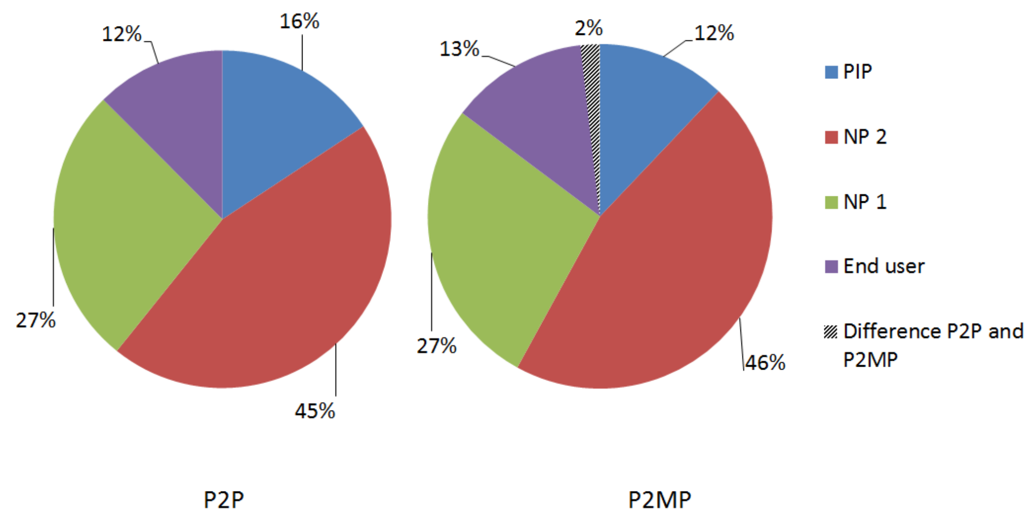

Figure 36: Comparison of the cost assignment per actor for churn in a P2P and a P2MP topology

Identification of the most important costs through Pareto analysis

The final step of investigating the cost for churn in a fiber open access scenario corresponds to the investigation of the single costs within the churn procedure. This is done, similarly to bitstream open access, using of Pareto charts (Figure 37 and Figure 38). Both the Pareto chart for a P2P and a P2MP topology have a similar behavior. The highest costs in both cases are the administrative subscription and termination of the end user, followed by the equipment cost of the ONT. These three costs correspond to 50% of the total cost. The next highest cost corresponds to the installation of the ONT at the end user's premises and is again equal in both cases. The next cost is the logical connection of the end user. Currently, already 75% of the total cost is assigned and is equal in both cases. The following cost is the first that distinguishes between both cases and corresponds to the transport to the street cabinet in case of a P2MP, and a logical disconnection in case of a P2P connection. Here, more than 80% of the total cost is assigned and therefore, the above-mentioned costs should be the first to tackle for optimization.

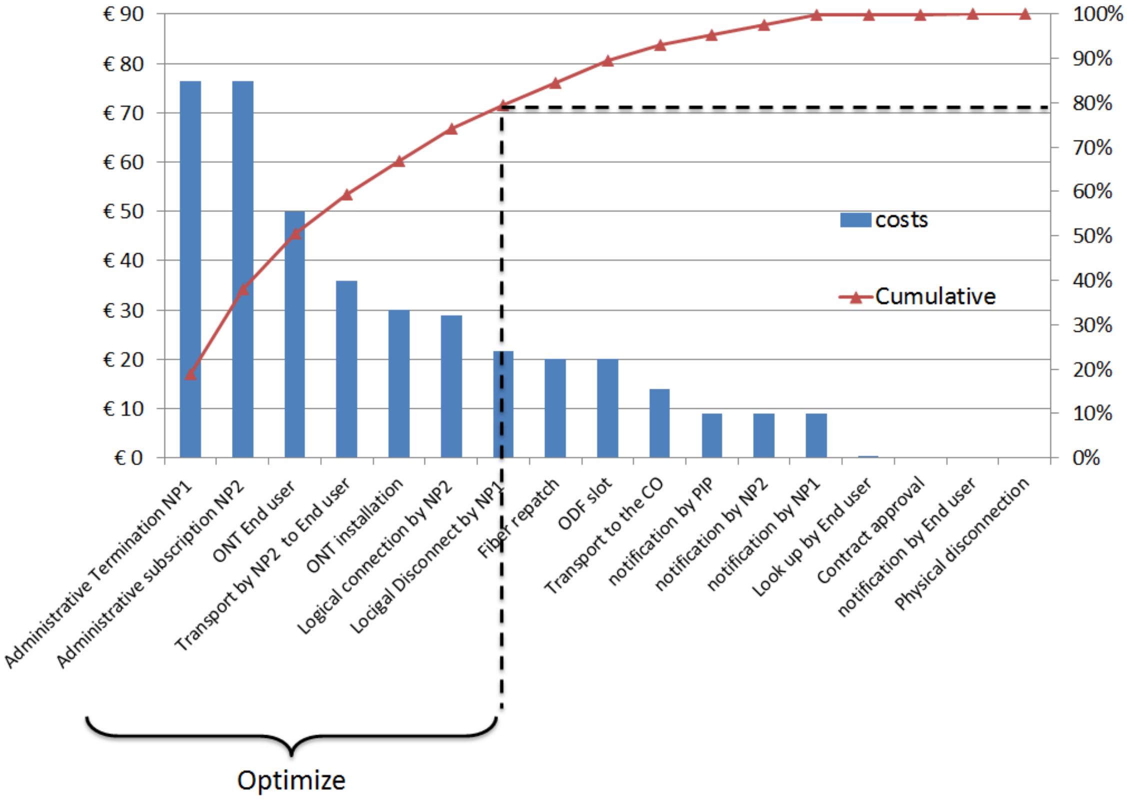

Figure 37: Pareto chart for P2P fiber open access

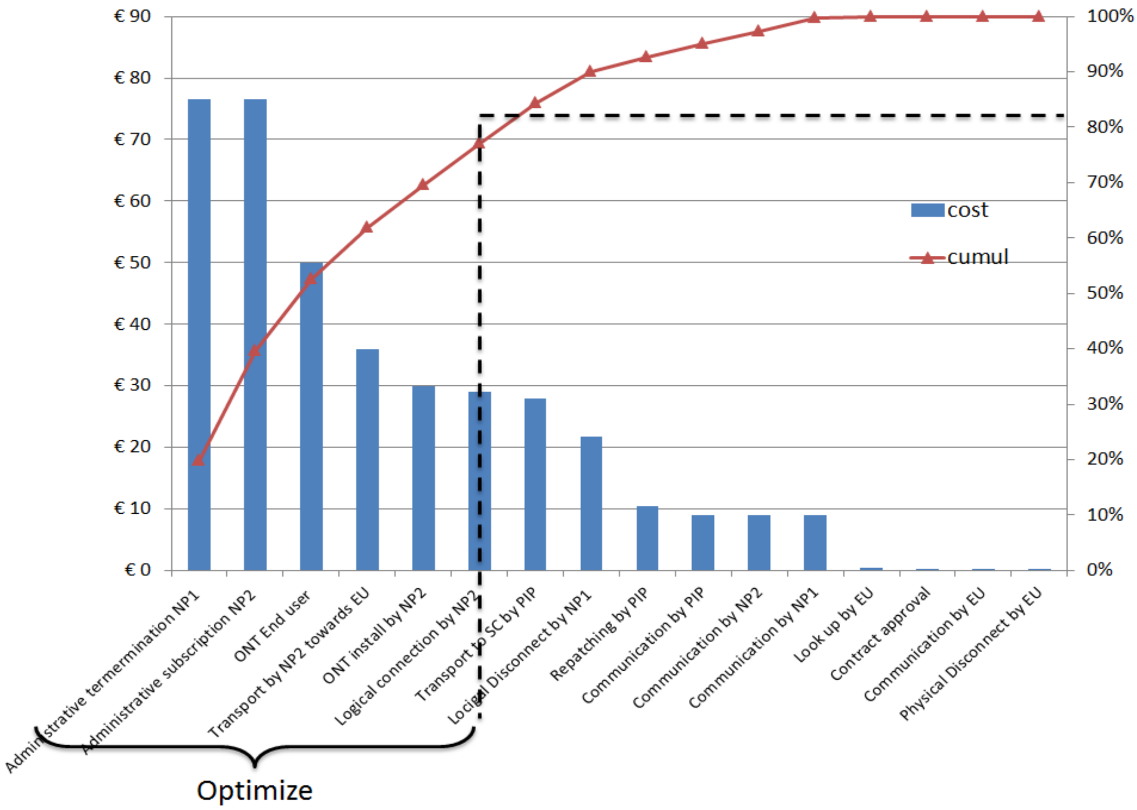

Figure 38: Pareto chart for P2MP fiber open access

Comparison of churn within bitstream open access and fiber open access

After the investigation of both churn within fiber and bitstream open access, both different churn procedures can be compared to each other. The total cost for an end user churning service providers is either € 420 or € 360 with the cheapest total cost corresponding to an end user installation. Churning between network providers on the other hand, corresponds to a total cost of about € 385 for a P2MP topology and € 395 for a P2P topology. The difference between the P2P and P2MP topology lies with processes and equipment. First, the supportive processes (transportation) are cheaper for a P2P technology. However, the patching cost is higher in the P2P topology and there is an additional ODF slot needed.

Within all types of churn, the transaction and working equipment are equal. The equality in transaction costs related to the interactions between the provider and the end user. As these interactions are independent of the offered service, the administrative procedures are the same. The equality in equipment cost corresponds to the assumption that the cost for an RGW and an ONT are the same. Therefore, the differentiation between the costs for churn only lies within the process costs. Within the supportive processes, this difference is attributed to the different transportations that are needed. In case of a provider installation, all types of churn have transportation to the end user in common. Furthermore, churn within fiber open access also contains the transportation to either the street cabinet or the central office. As a result, the supportive processes within fiber open access will be higher.

The difference in operational processes relates to the network layer specific operations. Within fiber open access, this corresponds to the patching of the fiber while for bitstream open access, this relates to the set-up of an OVC. This difference in operational processes also explains why bitstream open access is the most expensive if a technician provides the installation of the end user's equipment. Both types of churn have some common processes and these common operational processes have an equal cost (installation by a technician, logical connection, logical disconnection etc.). However, the cost for setting up an OVC is much higher than the cost for patching a fiber. Even though the labor cost for a technician and a network operator is different, this will not explain the significant difference between bot processes. The significant difference lies with the time spent at the process (Table 2). In case of an OVC configuration, the time spent is 1.3 hours. However, the cost of a fiber patch is either € 13 or € 10.5 depending on the topology. Dividing this cost by the unit labor cost of a technician results in a patch time of about 0.25 hour.

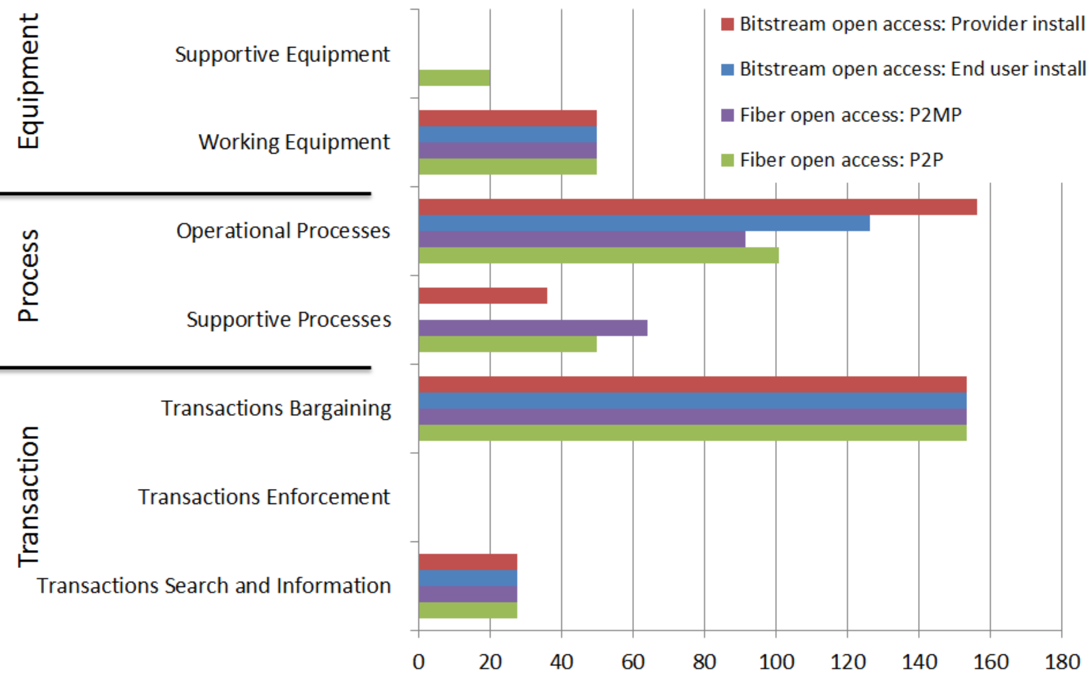

Figure 39: Comparison of the churn cost for both fiber and bitstream open access

5.5 Comparison of the cost for churn with values found in literature

Performing a reality check on the found results can happen in two ways. The first possibility corresponds to the verification of the found input values. Verification of the input can help in validating the output because a realistic input and a right procedure should also give a realistic output. The second possibility corresponds to a comparison with values found in literature and gives a validation.

Verification of the input values

The first section will focus on the validation on the used input values. The combination of realistic input values and the churn process will result in a credible cost for churn that can be compared to values found within industry. A first verification for the input values is found within [62]. Here, the execution times for the following processes are given: transport, administrative subscription, and fiber splicing. The duration for transport to the end user was listed as 0.3 hour and the round trip time would equal 0.6 hour. This trip would be performed by a technician with a labor cost of € 52. Combining these two values together gives a round trip cost to the end user's premise of € 31.2. However, this value does not include fuel costs and a cost for the car. As a result, this value would slightly increase and would near the used value within the model of € 36 for the transportation to the end user. The second value is that of administrative subscription. Here, the time spent for the administrative installation is 1.25 hours and compares to contract handling. The used input value within the model for administrative subscription was 1.7 hours and contained contract handling, cost assignment and billing. Comparing both contract handling times (1 hour versus 1.25 hours) shows that the used input value is a lower. The final value considers the fiber splice of the distribution fiber with a duration of 0.27 hour. This action would be performed by a technician and would correspond to a cost of about € 14 when using a unit labor cost of € 52. This value should be compared to the patching value at the street cabinet where the distribution fibers start (see section 3.1.2) of € 10.5

During an interview with a salesperson of Proximus (Appendix B), some cost values regarding the equipment and the installation were mentioned. First, the cost for the end user equipment was set at € 99 for a B-box 3 and at € 125 for a decoder. A decoder is used to receive digital television, and can thus be compared to the used cost for an RGW. However, these values are sales values meaning that the effective cost will be lower, but its price will still be higher than the used values for the ONT and RGW of € 50. Furthermore, the cost for a visit from a technician was fixed at € 75. This value is independent of the geographical location of the end user and the type of installation. This compares to the chosen input values of € 36 for the transport to the end user and an installation cost of € 30.

Comparison of the chosen input values to other values found in literature shows that only a significant difference is found for the cost of the end user equipment. Since the rest of the input and literature values have the same magnitude, the found output values should resemble values found in literature.

Verification of the output values

The second possibility for performing a reality check is by comparing values found in literature. Finding a reference value in literature for the cost of churn was more difficult. Within section 2.1.5, the cost for churn was examined and it was shown that this cost is threefold. This cost contained the lost revenue, the cost for reacquisition and retention, and the cost for the churn process itself. Within the existing literature, a lot of attention is spent on the lost revenue through the customer lifetime value and at the cost for reacquisition or retention. Here, customer lifetime value is defined as the net present value of the profit that you will realize on the average newly acquired customer during a given number of years [63]. Furthermore, the cost for reacquisition often is five to ten times larger than the cost for preventing a customer to churn. On the other hand, very little is found on the cost for the churn process itself.

Within [16] a churn cost of € 135 to € 165 was found for churn within fiber open access. This is much lower than the found values of about € 400 within this work. However, the found cost only applies to process costs and does not take into account transactions. The considered processes are the physical patching, the logical patching, and the replacement of the ONT. Here, the logical patching corresponds to the logical connection and disconnection at the different NPs. Furthermore, since the physical patching is described at the cross-connect ODF, the costs must be compared to the churn cost in a P2P topology within this work. The above-mentioned processes are performed by the PIP and the two NPs and correspond to following process costs: € 27 (PIP), € 21.75 (NP_1), and € 95 (NP_2). Together these costs sum up to € 143.75 and lie within range of the stated values for churn.

Another value for churn was found within [64]. Here, a cost per churn event was given between $ 200 (€ 170) and $ 600 (€ 520). The results of the model fall within this range with a minimum of € 360 for an end user churning service providers and installing the equipment himself and € 420 for an end user churning service provider with a service provider installation. Furthermore, it was stated that the cost for reacquisition is typically ten times higher than the cost for churn.

A third value of a churn cost of € 500 was found within [17]. However, this value is specified for wireless telecom but can still be used as an estimate. The fourth source [65] cited a number of different switching costs in the French broadband market. These switching costs go up to a maximum of about € 420. This is still in line with the found results for the switching costs. However, this source also list values that are a lot lower, which signifies that optimization is needed in order to stay competitive.

5.6 Influence of the churn rate on the needed revenue to compensate churn

In order to investigate a difference in churn rate, one can study the increase in monthly revenue that is needed to compensate the churn cost [26]. The formula below requires the number of years before a customer churns in order to calculate the additional revenue needed per month. This number equals the customer lifetime and can be calculated as the inverse of the annual churn rate. For example, if a company has an annual churn rate of 33%, a customer is expected to have an average customer lifetime of three years.

$$\sum_{i=1}^{n} 12 * A * \frac{1}{(1+r)^i} = cost\ for\ churn$$

A = the additional revenue needed per month
r = the discount rate, chosen at 0.09
n = number of years before a customer churns

A first examination considers the additional revenue that is needed in case that the total cost for churn is assigned to one operator (Figure 40). This occurs, for example, if the new or alternative service provider is responsible for both the terminating of the contract with the old SP and the creation of a new OVC by the NP. For example, if the annual churn rate is 10 %, the additional revenue that is needed to cover the expenses of churn is between € 4.5 and € 5.5 per month. In case the churn rate increases to about 20 %, which corresponds to a lower customer life time five years, the additional needed revenue will have increased to about € 8.

Annual churn rate	Customer Life Time (years)	Total cost			
		P2P topology	P2MP topology	Bitstream SP installation	Bitstream End user install
100%	1	€ 35,77	€ 35,09	€ 38,35	€ 32,35
50%	2	€ 18,65	€ 18,30	€ 20,00	€ 16,87
33%	3	€ 12,96	€ 12,72	€ 13,90	€ 11,72
25%	4	€ 10,13	€ 9,94	€ 10,86	€ 9,16
20%	5	€ 8,44	€ 8,28	€ 9,04	€ 7,63
17%	6	€ 7,31	€ 7,18	€ 7,84	€ 6,62
14%	7	€ 6,52	€ 6,40	€ 6,99	€ 5,90
13%	8	€ 5,93	€ 5,82	€ 6,36	€ 5,36
11%	9	€ 5,47	€ 5,37	€ 5,87	€ 4,95
10%	10	€ 5,11	€ 5,02	€ 5,48	€ 4,62

Figure 40: Additional revenue needed to compensate the total churn cost

The previous examination considered the cost assignment of the churn cost to one actor. However, each actor will be responsible for a different cost part. Figure 41 and Figure 42 show the needed revenue per month to compensate for the provider specific churn costs. In case of an end user churning service providers and a churn rate of about 15% [66], the NP should charge about an additional € 1.50 to compensate for the cost of creating a new OVC. This would be an additional € 2 for the old provider to compensate for the contract termination. The additional revenue needed for the new service provider depends on the considered scenario. In case the of a service provider installation, the needed revenue will be higher and will be about € 3. In case of an end user installation, this will be € 2.

Annual churn rate	Customer Life Time (years)	SP installation			End user installation		
		NP	SP1	SP2	NP	SP1	SP2
100%	1	€ 7,67	€ 9,74	€ 16,40	€ 7,67	€ 9,74	€ 10,40
50%	2	€ 4,00	€ 5,08	€ 8,55	€ 4,00	€ 5,08	€ 5,42
33%	3	€ 2,78	€ 3,53	€ 5,94	€ 2,78	€ 3,53	€ 3,77
25%	4	€ 2,17	€ 2,76	€ 4,64	€ 2,17	€ 2,76	€ 2,95
20%	5	€ 1,81	€ 2,30	€ 3,87	€ 1,81	€ 2,30	€ 2,45
17%	6	€ 1,57	€ 1,99	€ 3,35	€ 1,57	€ 1,99	€ 2,13
14%	7	€ 1,40	€ 1,78	€ 2,99	€ 1,40	€ 1,78	€ 1,90
13%	8	€ 1,27	€ 1,61	€ 2,72	€ 1,27	€ 1,61	€ 1,72
11%	9	€ 1,17	€ 1,49	€ 2,51	€ 1,17	€ 1,49	€ 1,59
10%	10	€ 1,10	€ 1,39	€ 2,34	€ 1,10	€ 1,39	€ 1,49

Figure 41: Additional compensation revenue per provider in bitstream open access

If an end user churns network providers, the needed additional revenue is shown in Figure 42. The additional revenues needed for the new and old network provider are independent of the used topology. Since the costs associated with the physical infrastructure provider (PIP) is dependent on the used topology, the needed revenue will differ. However, the difference between both topologies is small and if the annual churn remains below 33%, the difference will be smaller than € 0.5 per month.

		P2P topology						P2MP topology					
Annual churn rate	Customer Life Time (years)	PIP		NP1		NP2		PIP		NP1		NP2	
100%	1	€	5,72	€	9,74	€	16,40	€	4,31	€	9,74	€	16,40
50%	2	€	2,98	€	5,08	€	8,55	€	2,25	€	5,08	€	8,55
33%	3	€	2,07	€	3,53	€	5,94	€	1,56	€	3,53	€	5,94
25%	4	€	1,62	€	2,76	€	4,64	€	1,22	€	2,76	€	4,64
20%	5	€	1,35	€	2,30	€	3,87	€	1,02	€	2,30	€	3,87
17%	6	€	1,17	€	1,99	€	3,35	€	0,88	€	1,99	€	3,35
14%	7	€	1,04	€	1,78	€	2,99	€	0,79	€	1,78	€	2,99
13%	8	€	0,95	€	1,61	€	2,72	€	0,72	€	1,61	€	2,72
11%	9	€	0,88	€	1,49	€	2,51	€	0,66	€	1,49	€	2,51
10%	10	€	0,82	€	1,39	€	2,34	€	0,62	€	1,39	€	2,34

Figure 42: Additional compensation revenue per provider in fiber open access

5.7 Comparing the churn cost to other metrics

Within [67], the cost per home connected is given at € 1750 for a P2MP network and € 1900 for a P2P network. Within this source, the cost per home connected refers to all costs, including operational costs. As a result, an estimate of the operational expenses within a FTTH network can be calculated. The operational expenses consist of the maintenance and repair costs, customer relationship management, and continuous costs for housing and energy. The operational costs correspond to 18% (P2MP) and 21% (P2P) of the total cost over a period of 10 years. As a result, the operational expenses are about € 2.6 (P2MP) and € 3.3 (P2P) per month. However, these values are in the case of a 100% take-up rate. Here, take rate corresponds to the percentage of customers that are connected. In case the take rate is halved, the operational expenses will increase to about € 6 per month. These operational expenses are in line with another value found within [68]. Here, an operational cost of $ 5 (€ 4) is stated. Alongside the operational expenses, one can look towards the Cost Cash per User (CCPU). Next to the operational expenses as defined above, the CCPU also includes the servicing costs. On average, a value for the CCPU is found of about 20 € [63], [69]. Here, the churn cost is about twenty times higher than the monthly operational expenses. In case an end user churns, this monthly cost will be lost. This is compensated slightly by the fact that the end user will have to return the used equipment that could then be reused.

Cost per Gross Addition (CPGA) [63] quantifies the costs to acquire a new subscriber. This value is comparable to the reacquisition cost for an end user. Within the telecom sector, the cost for reacquisition will be around € 300. Alongside the found costs for the churn procedures, the total cost for churn will be around € 700 since companies will put effort into gaining their customers back.

Cost per home passed and cost per home connected are closely related. Here, a home passes refers to a home that is not connected to a network even though the infrastructure is available and [67] lists a home passed value of about € 1000 for a P2MP topology and € 1750 in case of a P2P topology. On the other hand, a value for home connected of about € 1200 is given for a P2MP topology and € 1900 for a P2P topology. Other values for home passed lie between € 570 for a dense urban area and € 1750 for a rural area [26]. Comparing this cost to the churn cost shows that in case open access is not present, and a new network has to be deployed in order to facilitate churn, the cost per end user will be doubled or even quadrupled. In case open access is present, the cost to connect a new end user compares closely to the calculated value for churn.

Within literature, two types of values for the Average Revenue per User (ARPU) are found. The first type considers the revenue for the PIP and corresponds to about € 10 [26], [70]. The second type values found relates to the different services being offered, here an average value of about € 30 is found [63], [71], [72], [72]. As both types of revenues are at either end of the spectrum, the assumption can be made that the ARPU of a network provider will be between both values and around € 20.

Closely related to the ARPU is the return on investment (ROI) (Figure 43). The return on investment is calculated as the revenues divided by the investment or in this case the churn costs. From the ROI and the ARPU, we see that all the incurred costs are compensated within nine months. In case of offering bitstream open access, this is even faster and occurs within about four months.

	Fiber open access		Bitstream open access	
	P2P topology	P2MP topology	Provider installation	End user installation
PIP	0,159	0,211		
NP_1	0,186	0,186		
NP_2	0,111	0,111		
NP			0,237	0,237
SP_1			0,280	0,280
SP_2			0,166	0,262

Figure 43: Return on investment for the different operators

5.8 Conclusion

Within this chapter, a model was discussed in order to calculate the different costs associated with the churn of an end user. The churn of an end user can occur in two distinctive ways. An end user can churn from one service provider to another or from one network provider to another. In case of an end user churning network providers, a distinction was made between a P2P and a P2MP topology. By specifying the chosen churn procedure, the model would gather the suitable input values and hand these over to a calculation module. This module then calculates the cost for churn for the given input values and a specific set of cost functions. Once the cost for churn is calculated, the results would be classified according to a cost categorization or a responsible actor.

After the definition of the model, the results for the churn of a single end user were investigated. When an end user churns service providers, two scenarios where taken into account. The first scenario covered the installation of equipment by the service provider, while the second scenario covered the installation of the equipment by the end user. The former has a total churning cost of about €420 and the latter is about €60 cheaper. The difference between both scenarios was contributed to the reduction of installation and transportation costs. The majority of the costs for an end user churning service providers is determined by process and transactions costs. Analysis of the responsible actors showed that the new service provider is responsible for the majority of the incurred costs, followed by the original service provider and the end user. Pareto analysis showed that administrative termination and subscription or the highest costs incurred and are therefore best suitable for optimization. The final part of the investigation for churning within bitstream open access covered a different opportunity cost for the end user. This analysis showed that the cost assigned to an end user is determined by the equipment cost and the transaction costs related to search and information. The process costs showed to be negligible for a churning end user.

Next to the investigation of a switch in service provider, the switching between network providers was examined. Here, the distinction was made between churn over a P2P topology and churn over a P2MP topology. For both topologies, the majority of costs are assigned to transactions and are equal in both cases. The difference between both topologies therefore lies with the processes and equipment. The difference in equipment cost is solely related to the presence of an ODF slot in case of a P2P topology whereas for process costs, two effects come into play. The supportive processes are cheaper for a P2P topology as less transportation is needed. The operational processes on the other hand are cheaper for a P2MP topology as fewer installations have to be performed. An examination of the cost per actor showed that the only difference between both topologies lies with the physical infrastructure provider and results as combination of the aforementioned differences. Finally, a Pareto analysis showed that the administrative termination and subscription are the highest cost factors.

Finally, verification of the input values showed that the used input values have a similar magnitude as values found in literature. Furthermore, found values for the cost of churn in literature showed the same magnitude as the result from the model. Furthermore, in case of an annual churn rate below 33%, an additional revenue of up to € 3 is needed to compensate the costs incurred when customer churn.

Chapter 6 The churn of end users: optimization of the procedure and minimization of costs

Previous chapters covered the identification and modeling of the cost related to the churn of end users. The next step in the analysis of churn is the study of optimization possibilities. Process optimization is an important aspect within companies as it will not only reduce costs, but also boost efficiency, yield higher quality products, etc. In order to optimize the churn procedure and correspondingly, minimize the cost related to churn, one can focus on minimizing the different aspects of churn. Within Chapter 4, a cost breakdown structure was defined and the different churn procedures were investigated. From the cost breakdown structure, one can distinguish three types of churn costs: equipment, processes, and transaction costs. Minimizing the costs related to one category will overall benefit the entire churn cost. Therefore, within the first section of this chapter, a summation of different techniques is given to optimize each single aspect of the churn cost. The second part of this chapter will focus on the effective implementation of these techniques in order to achieve quantitative results.

6.1 Optimization of churn

Within this section, the different possibilities for optimization are investigated. These optimizations are linked to the cost breakdown structure as defined in Chapter 4 and each optimization will focus on one branch of the cost breakdown structure. Therefore, the used optimization will either focus on equipment, processes, or transactions. The optimization of equipment will focus on standardization to reduce the component cost and increase the interoperability. Process optimization will be based on lean manufacturing in order to retain only value adding activities while reducing all non-value adding activities. The optimization of transactions will occur through automation of processes and the reduction of information asymmetry.

6.1.1 The optimization of processes

The optimization of processes is based on the application of lean manufacturing, which is defined as "a systematic approach to identifying and eliminating waste through continuous improvement by letting the product flow at the pull of the customer in pursuit of perfection"[74]. Within this definition, pull refers to any succeeding node making an order request from a preceding node. The preceding node will then react by producing the order either through internal operations or by ordering a pull to another preceding node. Furthermore, the definition speaks of the elimination of waste. Here, waste is seen as all non-value adding activities and different types of waste can be identified [75]:

- Waiting: Waiting, also known as queuing, refers to time periods of inactivity in a downstream process that occur because an upstream activity does not deliver on time. Examples within telecom include the waiting of an NP for the PIP to repatch the dedicated fiber of an end user.

- <u>Defects:</u> Defects apply to a defective product or service and introduce additional costs in four ways. First, materials are used to produce a faulty product or service. Second, the labor used to produce the faulty product is lost. Third, additional labor is required to either rework the product and repair the defect or even reproduce a new product. Fourth, customers can and will complain about their defect. For this reason, additional labor is required to address the customer complaints. Examples include a defect RGW or ONT.
- <u>Overproduction</u>: Overproduction occurs when operations continue after they should have stopped. The result of overproduction is products being produced in excess which results in excess inventory costs.
- <u>Transportation</u>: Unnecessary motion or movement. Ideally transport should be minimized for two reasons. First, it adds time to the process during which no value-added activity is being performed. Secondly, in case of physical products, the transportation handling could damage the products. For example, in case an end user switches NP in a P2P topology, the PIP will send a technician to the CO to repatch a fiber. The PIP will have to perform this action for every churning end user and a large amount of transportation is needed. This can be optimized by using an automated cross-connect at the patch panel or by grouping multiple churning end users in one single transport.
- <u>Inventory:</u> Inventory as waste refers to any form of product, either raw materials, work in progress, or finished good that has not yet produced an income by the producer of for the customer. In this case, the product will not be processed to add value and can be seen as waste.
- <u>(Over-)Processing:</u> Over-processing refers to additional work that is needed through a poor choice of used tools and design. This can include using components that are more precise, complex, or of higher quality than is required.

The elimination of the different types of waste are all directed towards the goals of lean manufacturing. The goals of lean manufacturing include the improvement of quality, the elimination of waste, the reduction in production time, and an overall reduction of the total cost. The above mentioned types of waste apply mostly to a product manufacturing system. However, they can be translated to a service oriented sector. In this case, waiting becomes delay as customers wait for the delivery of the service; defects can be translated into faulty service provisioning and will have to wait for the provider to restore the service; processing corresponds to the duplication of work, which means the re-entering of data, repeating details on administrative forms, etc. The other service wastes are unnecessary movement, unclear communication, service quality failure, and lost opportunities of acquiring new customers [76].

Even though lean manufacturing is mostly applied to production facilities within factories, it can also be applied to a telecommunications environment [77]. By combining the lean manufacturing principles with agile manufacturing, a suitable mix for the telecommunication sector can be achieved. Agile manufacturing focuses on creating flexible or virtual organizations over multiple interfaces, to meet customer demands in a very specific and fast manner [77]. Even though lean can be applied to the operational processes without any problems, it must also be applied to the administrative part and offices to cover the entire churn procedure. Within administration and offices one does not investigate the flow of materials or products, but the flow of information. This tends to be more difficult to study as information is a not tangible and is less visible.

Lean within offices applies four basic steps: stabilize, standardize, visualize, and improve. Stabilization refers to creating predictable and repeatable output. Standardization corresponds to consistently followed procedures by all people who perform actions. Visualization refers to the use of visual communication as this is the most effective and efficient method of communication. Finally improve relates to the implementation of continuous improvement. Here, every employer is engaged in improving performance and where every improvement, whether large or small, is a step in the right direction [78].

Next to the optimization of the operational process one can look towards the optimization of administrative processes, which is important for numerous reasons. First, as these processes are an important source of costs for companies that offer services, optimization of administrative process will result in cost savings. Second, suboptimal administrative processes are not solely a cost, but can also act as a source for annoyance for customers. As a result, the perceived quality of the customer service will be lower. Finally, a simple administrative process is easier and cheaper to computerize than an unnecessary complicated process. Once the administrative processes are documented, one can start simplifying the processes and eliminate unnecessary administrative work. After the simplification, one can automate the resulting process and minimize the corresponding cost.

6.1.2 The optimization of transactions

Next to the processes, one can look towards optimizing transaction costs. Transaction costs were first defined by Williamson [49]. Within the transaction cost framework, it is stated that the transaction is seen as the basic unit of economic analysis and that “a transaction occurs when a good or service is transferred across a technologically separable interface” [49]. As a result, transactions occur between two separate companies. Furthermore, transactions differ from each other based on the uncertainty concerning the occurrence of a transaction, the frequency of the transaction, the ease of measuring the transaction and the asset specificity of the transaction.

Optimization can occur on each aspect of the transactions. Furthermore, Jeffrey H. Dyer states in [79] five different propositions on how to reduce transaction costs in an automotive industry. Although these propositions are based on the automotive sector, they can be converted to the scenario of an access network. This will be done based on the corresponding aspects of the transaction cost (uncertainty, frequency, and asset specificity.

These propositions are:

- The higher the probability of repeated exchange, the lower the transaction cost per unit of exchange.
- The greater the total volume of exchange between transactors, the lower the transaction costs per unit of exchange.
- The greater the degree of information sharing, the lower the information asymmetry, and the lower the transaction cost.
- Self-enforcing safeguards result in lower transactions than long-term legal contracts.
- Relation specific investments serve to increase commitment and the cost for defection, thereby resulting in a lower transaction cost.

The first aspect of transactions and transaction costs is the uncertainty of the transaction. By reducing the uncertainty, the transaction cost will be minimized. Standardization is one way to reduce uncertainty. Standardization is, in essence, agreeing to a specific way of doing something. This could be the making a product, managing a process, delivering a service, or performing transactions in a specific way. Increasing standardization influences both search and information costs as well as equipment and process costs. Search and information costs are reduced through clear documentation and easy availability of standards [16]. Furthermore, standardization will impact equipment and process costs as interoperability is ensured. A second way for uncertainty reduction is achieved through information sharing. Dyer (third proposition) states that the greater the degree of information sharing, the lower the information asymmetries and the lower the transaction costs, as less search and information costs will arise. An example of information sharing is the use of integrated databases.

The second aspect of transaction costs relates to the frequency of the transactions. Dyers first and second proposition both affect the frequency of the transaction: repeated transactions with a small set of suppliers, and economies of scale and scope through transacting with that small supplier group, will have a positive impact on the costs. In case of repeated transactions with a small set of suppliers (NPs and SPs for an access network), the transaction costs are reduced for two reasons. First, for a small set of providers, the cost of opportunism or defection will be higher since alternatives will not be readily available. Second, through repeated transactions more opportunities will arise to correct for transaction inequities between both providers. The first proposition of Dyer focuses on the frequency of the transactions. The more transactions occur, the more experienced the actors will be and the lower the transaction costs. For example, if a provider often cooperates with another provider, communication between both providers will become fluent.

6.2 Results of optimization

The previous section studied different theoretical methodologies for optimizing the churning procedure and minimizing the corresponding costs. Within this section these techniques will be applied to the different churn procedures. Each optimization will tackle one specific cost before introducing a new optimization. Furthermore, every new optimization will build upon the previous ones. This way, the total cost for churn will decline after every optimization and the final optimization will combine all other optimizations together. The chosen optimization focus on the highest costs found by applying a Pareto analysis to the churn cost (Chapter 5) and on processes that will simplify the flow of the churn procedure.

6.2.1 Optimization: introduction of standardization

A first optimization is based on standardized end user equipment. By using a standardized RGW and/or ONT, costs can be saved when an end user churns. The standardized equipment can be used independent of the current provider and therefore, a first major cost saving occurs at the end users premises equipment. The standardized equipment is installed when the end user first connects to the network. When the end user wants to switch providers no change in equipment is needed. A direct consequence of this approach is the savings on the following aspects: equipment cost and process costs. The first cost saving of the equipment is straight forward. By not changing the equipment, no new equipment must be purchased. However, by not changing the equipment, the overall age of equipment will be higher and a higher risk of failure will occur. This will have an impact on the operational expenses of the providers.

The second cost part involves process costs. For operators that use a standard, the equipment becomes inter-operable. However, complying with this standard will require adjustments to the equipment. This will result in a slightly higher development cost for the equipment. However, standardized components are 20% to 60% cheaper than customized components [80]. As the ONT or RGW is inter-operable, the provider will not have to plan for a technician to travel to the end user's premises. This results in the elimination of the transportation to the end user and the elimination of installing new equipment. Both processes fit into the lean manufacturing philosophy as both costs are non-value adding. Transportation corresponded to wasted time, while installing corresponded to over-processing. The end user will still have to configure its equipment in order to receive the wanted service. Through the use of standards, this reconfiguration should be well-documented and easy to perform.

Even though costs are reduced, one must take into account several things. First, the standards for the equipment must be defined. By defining a standard, one ensures quality, accessibility, interoperability, etc. However, the development of a standard is not done in a few weeks but can take on average five years [80]. Furthermore, the same source states that the costs for industry-wide standards are not easily quantified. Standards development is done by a panel of experts and consists of several aspects [81]. First, the development of a standard happens as organizations such as the ISO respond to a request from the industry. Second, the panel that develops the standard comprises of members from different sectors. These sectors include industry members, consumer associations, academia, governments, NGOs, etc. Finally, the approval of a standard is based on a consensus between all involved parties.

Adopting a standard will have positive effects, both short and long-term, on the cost and the competitive status of those using a standard. The competitive edge occurs as a company that helps developing a standard can influence the content of the standard and results in insider knowledge. As another competitive edge, by using a standard, companies avoid being dependent on a single supplier. This gives a wider choice for picking a supplier while still keeping the same degree of quality [80]. Furthermore, the involvement in developing a standard gives the additional benefit that a company can anticipate on new regulations/laws and therefore avoid future costs. Other advantages of using a standard include simplified contractual agreements between companies, lower trade barriers, and lower transaction costs.

For the implementation of the standardization, the following cost aspects were taken into account. First, the provider will not have to send out a technician, therefore saving the transport and installation of the technician. Second, the elimination of the equipment cost. Using standard equipment comes at a cheaper equipment cost, but this occurs when a new end user connects, not when an end user churns. Here, the equipment is already purchased and will still be used. Since no technician has to visit, the end user can perform the reconfiguration, this is accounted by a small amount spent by the end user. Since the development of a standard takes multiple years and involves numerous parties, the costs for the development are not easily quantified. Therefore, the development of the standard will not be taken into account. Furthermore, this optimization will tackle three high costs as identified through the Pareto analysis in Chapter 5. These costs are the end user equipment, the transportation to the end user, and the installation.

The first optimization of standardized equipment already has a significant impact. The total cost for bitstream open access changes from about € 420 to about € 310 or a reduction of about 27%. In case of fiber open access and a P2P topology, the total cost for churn reduces from about € 400 to about € 280 which corresponds to a reduction of 30%. Finally, the cost for fiber open access and a P2MP topology is reduced from about € 385 to about € 270 and equals a reduction of 30%.

From Figure 44, we notice that in the case of bitstream open access, standardization results in the reduction of all the costs related to both supportive processes and equipment. This occurs as the only supportive process present for churn in a bitstream open access environment is the transportation to the end user. Furthermore, as the end user does not have to purchase a new RGW, the cost for working equipment is eliminated as well. The third cost category that is reduced is operational processes. This reduction of about 30€

corresponds to the elimination of the installation of the RGW. As a result, the cost for operational processes will be reduced by about 20%.

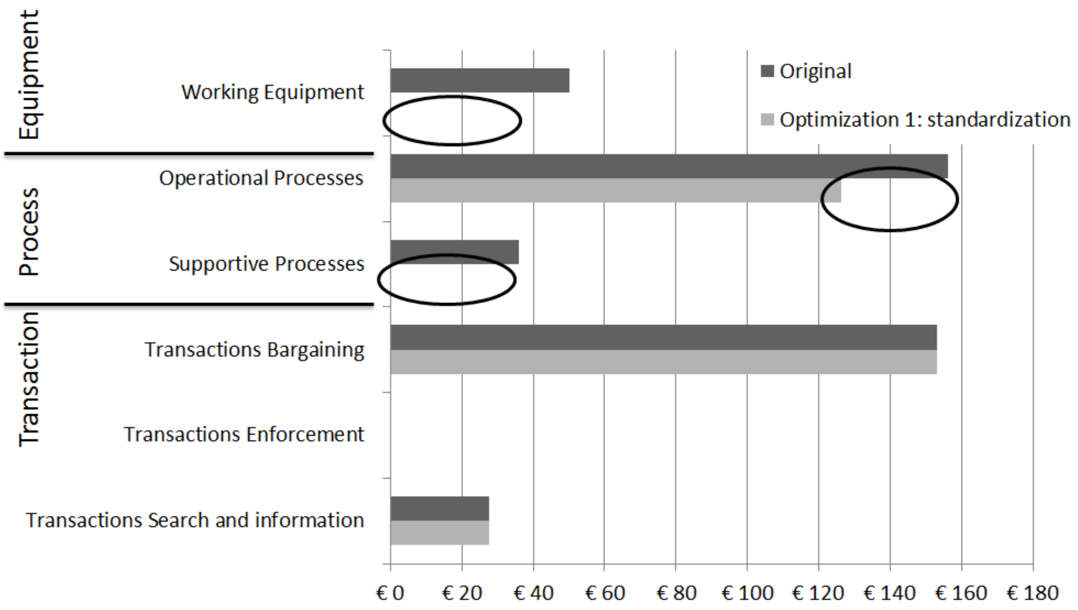

Figure 44: Bitstream open access, standardized equipment

In the case of fiber open access, the results for the equipment assigned cost is the same. Here, for both a P2P and a P2MP topology, the equipment cost during churn is reduced. Due to interoperability of the equipment at the end users side, no new equipment must be purchased. For the process costs, a significant difference is noticed. First, the operational process cost is reduced by about one third as the installation of the ONT by a technician is eliminated. Second, the cost for supportive processes is more than halved for a P2MP topology and even reduced by 70% in case of a P2P topology. The first transportation, which is independent of the topology, is the one towards the end user. This transportation is eliminated as no new ONT has to be installed by a technician. The second supportive process corresponds to the transportation of technician to either the street cabinet or the central office in order to repatch the fiber. As the distance to the central office is shorter than that towards a street cabinet, the effect on the supportive processes will be larger for a P2P topology than for a P2MP topology.

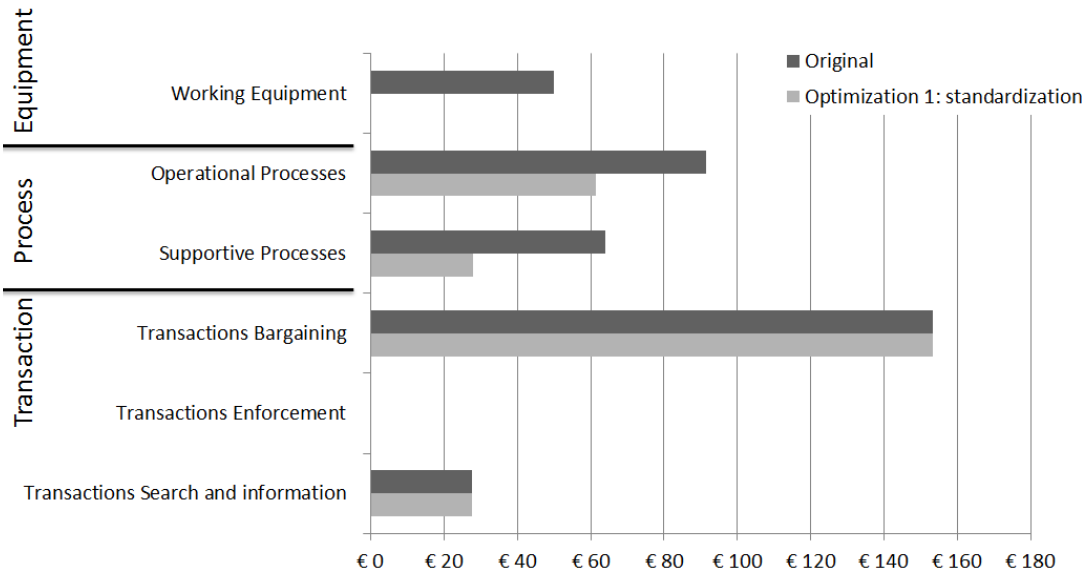

Figure 45: Fiber open access, P2MP, standardized equipment

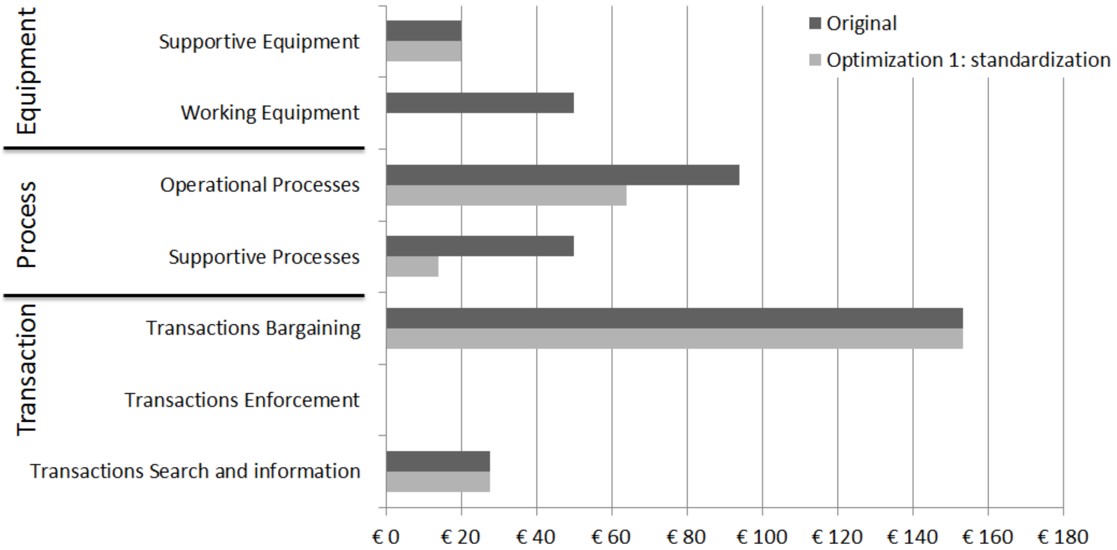

Figure 46: Fiber open access, P2P, standardized equipment

Effect of standardization on the assignment per actor

Investigating the effect of optimization through standardization shows an effect on two of the four responsible actors. The first effect is attributed to the new provider. This is the new service provider in case of bitstream open access and the new network provider in case of fiber open access (Figure 47). As the transportation towards the end user and the installation of the new equipment is eliminated, the cost for the new provider will be reduced. In case of fiber open access, the new NP (NP_2) will have an overall reduction by about one third, independent of the used topology. This reduction is only assignable to process costs, the transaction costs will remain the same. The second actor which notices a reduction in costs is the end user. As the cost for the new equipment in both fiber and bitstream open access is eliminated, no more equipment costs will have to be made. This greatly reduces the costs for the end user.

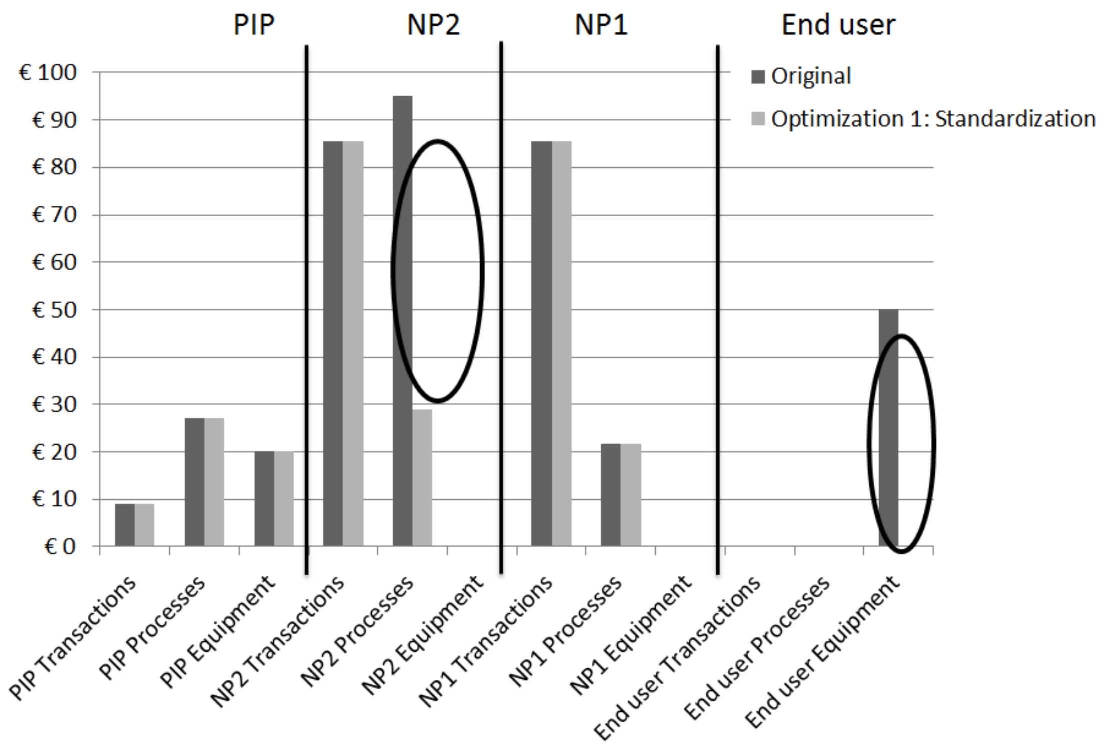

Figure 47: Fiber open access, P2P standardized equipment

Table 3: Churn costs for the different types of open access after the first optimization (costs in euros)

	Bitstream	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization 1: Standardization	307.2	278.8	270.3

6.2.2 Optimization: reduced patch cost by pre-connectorized fibers

The second optimization is only applicable to fiber open access. Whenever an end user decides to churn, the PIP must send a technician out in the field to perform a fiber patch. This patch is either performed at the street cabinet in case of a P2MP topology or at the CO in case of a P2P topology. When the technician arrives at the right spot, he will cut the fiber to terminate the physical connection and splice the fiber to make a new connection to the right network provider. By using optical connectors, the need for splicing is eliminated. This will result in 50% of the time saved compared to fusion splicing when it comes to making a new connection [82]. Furthermore, trained technicians are no longer required. This reflects in the “hourly labor cost that can drop significantly up to about 40%, depending on the operators cost structure” [82]. However, one must install a connector head/jumper onto the fibers at some point in time. Logically, this is the first time the end user is connected to the new access network, or the first time the end user churns. As there is no limit on how many times an end user can churn, it is uncertain whether the end user already churned or not. To make the application of a connector to the fibers uniform over all end users, it is assumed that this is best done when the end user is first connected to the network.

In order to examine the effect of this optimization the reduced labor cost and time spent on patching are taken into account. Previously, a patching cost of € 13.5 was given for a P2P topology. Assuming that a technician, with a labor cost of € 52/hour (section 5.2), performs this action, one calculates the duration to be about 0.25 hour. Applying the optimization, the time spent and the labor cost is reduced with the maximum amount [82]. The new hourly labor cost is 0.6 * € 52 = € 31.2 and the time spent is 0.5*0.25 h = 0.125 h. This results in a new reconnecting cost of about €3.9. The best case scenario will not be achieved from the start, but one can assume that once the technician is experienced with the reconnection process, a best case scenario can be achieved.

This optimization will reduce the cost for fiber open access by about € 10 resulting in a cost between € 260 and € 270 for both a P2P and a P2MP topology. Even though this reduction seems minor compared to the introduction of standardized equipment, the optimization is still relevant. As the reconnecting of the fiber is now done using optical connectors, it can happen much faster and fewer errors will occur since the process is simplified. As a result, one single technician can complete a larger number of connections per hour thereby increasing efficiency and reducing the overall amount of technicians needed to perform all physical reconfigurations at the patch panel or the splitters.

Table 4: Churn costs for the different types of open access after the second optimization (costs in euros)

	Bitstream	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization 1: Standardization	307.2	278.8	270.3
Optimization 2: Pre-connected	307.2	269.7	262.9

6.2.3 Optimization: Combining the churn of multiple end users together

Previously, it was assumed that the technician would go to the CO or street cabinet, terminate the existing physical connection and make a new connection to the right NP, and then would move back. This procedure would then be repeated for every churning end user.

In case of a P2P topology, all patches happen at the same location, namely the ODF at the CO. However, the technician can make this transport once and make multiple connections or multiple churning end users at the same time, and then move back. As a result, this one truck roll is shared among multiple end users and this reduces the non-value adding activity of the transportation significantly. Figure 48 shows the effect of grouping multiple end users on the total process cost. The total process cost starts at about € 70 and by increasing the number of grouped end users, the process cost will decline to about € 55. Grouping the first few churning end users from zero grouped to a few grouped end users will have a larger effect than grouping a higher number of end users. When more than 10 end users are grouped, adding an additional churning end user per group will yield only a reduction of less than 0.2% compared to the original process cost. Therefore, the maximum number of grouped end users is chosen to equal 10. An alternative option is choosing a higher number of grouped end users so that a technician can spend a full morning or afternoon at the central office performing connections. In this case, assuming a half day of work equaling at max 4 hours and a connection time of 0.125 hours (section 6.2.2), this would correspond to the grouping of 32 end users.

This optimization only has a cost impact on the PIP. Furthermore, this action will only affect the supportive processes of the PIP. By grouping up to 32 churning end users, the total cost is reduced from about € 270 to about € 255 per churning end user or a decrease of 5%. Figure 49 shows that, by introducing grouped patching at the CO, the transportation seems to be nearly eliminated. However, this elimination has to be nuanced. The transportation will still exist, but is shared amongst multiple end users. As a result, the cost that is attributed to transportation per end user is significantly reduced.

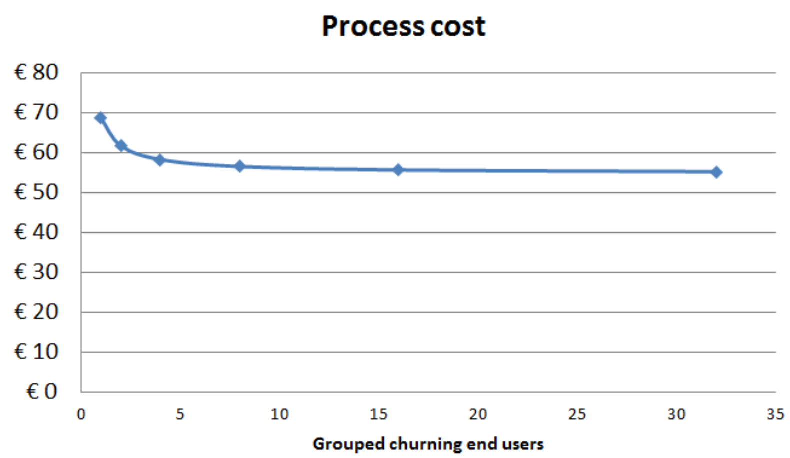

Figure 48: Effect on the process cost for grouping end users in a P2P topology

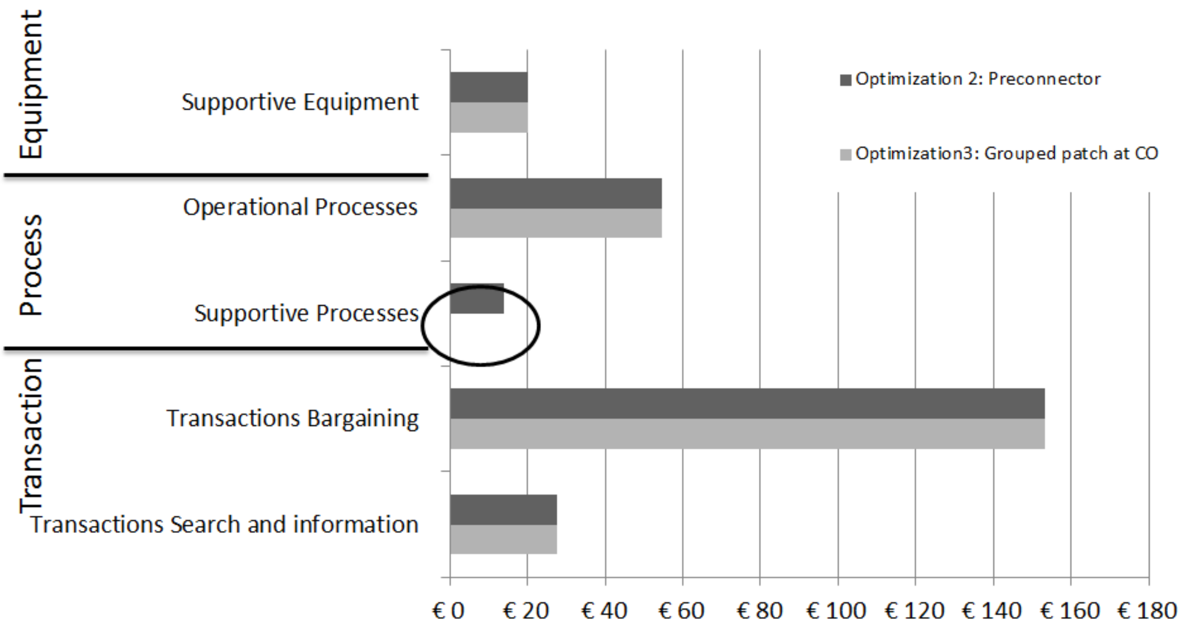

Figure 49: Effect of grouping 10 churning end users in the CO

Table 5: Churn costs for the different types of open access after the third optimization (costs in euros)

	Bitstream	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization: Standardization	307.2	278.8	270.3
Optimization: Pre-connected	307.2	269.7	262.9
Optimization: Grouped	307.2	256.1	262.9

The grouping of churning end users turns out to be more difficult in case of a P2MP topology. Here, the physical reconnection is made at the street cabinet by connecting the fiber to the right splitter. As churning end users do not have to be assigned to the same splitter at a street cabinet due to geographical constraints, it is difficult to combine even two churning end users at the same street cabinet. By increasing the size of the splitters within the street cabinet, the probability of two end users churning at the same street cabinet is increased, but it will still remain low.

Another approach to the grouping of churning end users within a P2MP topology is based on the birthday problem. The birthday problem is used in probability theory and relates to the probability that, in a set of n randomly chosen people, at least some pair of them will have the same birthday. Translating this to the grouped patching of multiple end users in a P2MP topology, one can calculate the probability that at least one churning end user has the same street cabinet as any other churning end user. Formula 6.1 shows the probability of at least two end users churning on the same street cabinet where A equals the number of street cabinets and B the number of churning end users.

$$Prob = 1 - \frac{A!}{A^B\ (\ A-B)!} \tag{6.1}$$

Figure 50 shows this probability for different splitting factors. Here, a splitting factor of 32 means that within each street cabinet the signal of one distribution fiber is split into 32 different distribution cables towards the end user. In order to calculate the total number of street cabinets, a reference population of 20.000 end users was chosen [33]. From the figure, we notice that the higher the splitting factor is, the faster the graph will approximate a probability of one. In case of a splitting factor of 32, it takes about 75 churning end users for a 0.99 probability that at least two churning end users will be on the same street cabinet (Table 6). When the splitting factor is increased to 128, it takes about 40 end users for a 0.99 probability of at least one shared street cabinet. When looking for a 50% chance of at least two end users sharing a street cabinet one needs 15 churning end users in case of a splitting factor of 128, and up to 59 in case of a splitting factor of eight.

Table 6: Number of end users needed to achieve at least one common street cabinet.

	Splitting factor	8	16	32	64	128
50%		59	42	30	21	15
75%		84	59	42	30	21
99%		152	107	75	53	37

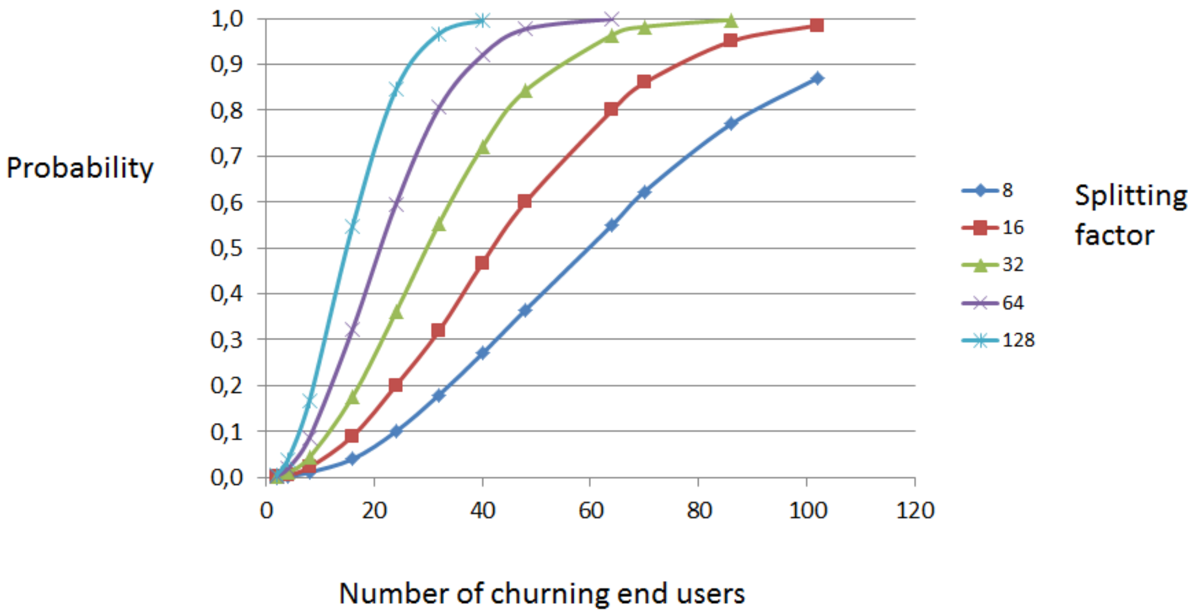

Figure 50: Probability for at least one shared street cabinet for different splitting factors

The results above show that in case of a splitting factor of 128, about one in 37 truck rolls could be saved. However, a far better optimization can be found in case no standardized equipment is used. In this case a technician can both combine the transportation to the street cabinet and the end user's premises into one single trip, thereby reducing the transportation cost by about 50% per end user since the street cabinet and the end user will be close to each other.

6.2.4 Optimization: simplified administrative subscription

In the current telecommunication sector, end users have little to no bargaining power. A consequence of this lies with the fact that, when an end user goes to a provider a limited amount of offers are present. When looking to providers within Belgium, [71] and [83], only three broadband offers are presented. This includes a low, medium, and higher cost offer. As these offers are standardized, a churning customer will choose one of the proposed offers with a standard price. By having standard prices, the assignment of costs can occur automatically when the contract of the churning end user is handled. This way a first saving of 0.5 hour can be accounted when the administrative subscription is performed of a churning end user. This cost savings correspond to the elimination of the assignment of the cost to the end user since it is now automated (Appendix B)

A second aspect of the administrative subscription that can be simplified is the contract handling itself. Using a company-wide database simplifies the administrative subscription for a churning end user. When the contract is handled, the following information will be imported into the database: personnel information of the customer (this includes the name, address, birthday, etc.), the type of requested service, the time and date a technician can come by if the end user does not want to perform the installation by himself. This way, one single person can perform the whole contract handling. This person will most likely be a sales person. The time spent by this sales person can go as low as ten minutes. However, since not everyone works as fast, the time spent at administrative subscription was estimated to average 15 minutes (Appendix B).

Studying the effect of this optimization on the churn cost within a P2P topology, one notices only a difference within the transaction costs, and more specifically the bargaining cost. This cost is reduced from € 180 to about € 125, which corresponds to a decrease of about 30%. As the administrative subscription is performed by the new operator, this is NP_2 in case of fiber open access or the SP_2 in case of bitstream open access. Furthermore, this optimization tackles the highest cost as found in Chapter 5.

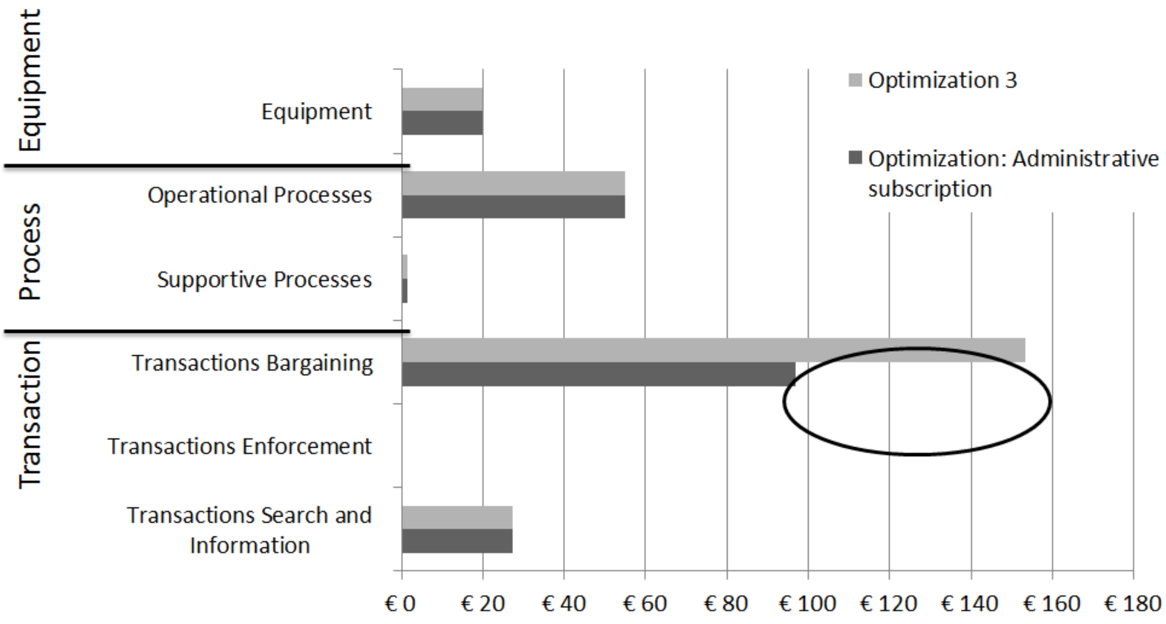

Figure 51: Effect of optimization of administrative subscription on the cost categories for a P2P topology

Table 7: Churn costs for the different types of open access after the fourth optimization (costs in euros)

	Bitstream	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization: Standardization	307.2	278.8	270.3
Optimization: Pre-connected	307.2	269.7	262.9
Optimization: Grouped transport	307.2	256.1	262.9
Optimization: Administrative subscription	250.95	200.85	206.67

The administrative subscription can be further optimized by removing the distribution of the first bill from the process. This first bill contains the installation costs, etc. However, one can also add this to the first monthly bill. Since the cost for the monthly billing will already occur during the operational phase, it is not needed to send an additional bill upon installation. This would result in an additional savings of about € 10.

6.2.5 Optimization: Administrative termination

Next to the administrative subscription, the administrative termination was found as a major cost within the Pareto analysis of chapter 5. As one can simplify the administrative subscription process, one can also simplify and automate the administrative subscription process. This process consists of the assignment of a final cost, the distribution of the bill, and the checking of payment. When an end user terminates his contract, the following aspects must be taken into account. First, no termination fee is required due to the Belgian telecom law (2.1.6). Second, the end user must specify for which products he wants to terminate his contract. Next, the end user must specify the end date of this contract. For example, the end user may choose to immediately terminate the contract or that the contract is terminated at the end of the month. Finally, in case the end user rented equipment, such as RGWs or ONTs, he must return this equipment to the provider (Appendix B).

Similar to the optimization of the administrative subscription, one can automate the assignment of the final cost. Next, the distribution of the bill will remain the same as throughout the un-optimized scenario. The third and final aspect involves the checking of payment. Within the previous optimization, a company-wide database was introduced. A benefit of this integrated and company-wide database is the fact that both accounting and customer information are integrated. As a consequence, one person can terminate the contract in the database and can also check with one click the financial status concerning payments. However, one must nuance this by stating that the operating person must have permission to access both segments of the database. Since the terminating of the contract within a database as well as the checking of payments can be done with a few simple clicks, the time spent at administrative termination can be reduced significantly. Within this optimization the customer service employee can perform the administrative termination in 15 minutes (Appendix B).

Table 8: Churn costs for the different types of open access after the fifth optimization (costs in euros)

	Bitstream	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization: Standardization	307.2	278.8	270.3
Optimization: Pre-connected	307.2	269.7	262.9
Optimization: Grouped	307.2	256.1	262.9
Optimization: Administrative subscription	250.95	200.85	206.67
Optimization: Administrative termination	194.7	144.6	150.42

Optimizing the administrative termination only affects the original provider. In case of bitstream open access, this will be SP_1 while this is NP_1 in case of fiber open access. This optimization will not have any effect on the assigned cost for other actors. Furthermore, since the cost for administrative termination is classified as a bargaining cost, this optimization will impact the transaction costs. The cost for the old provider is reduced from about € 110 to about €50, which corresponds to a cost saving of 55%.

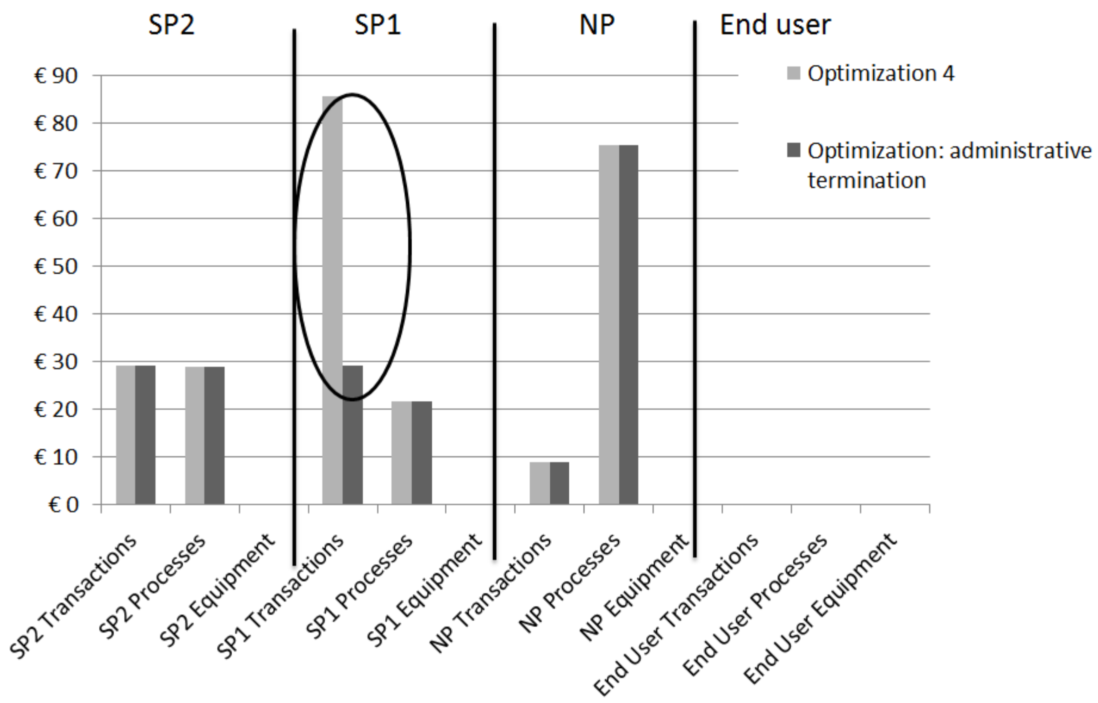

Figure 52: Effect of the optimization of administrative termination

6.2.6 Optimization: Cross-company database

The previous optimizations of administrative subscription and termination introduced a company-wide database. By introducing this database, all administrative process within a company could be handled by one person. The next step is linking this database to the database of other cooperation companies. This would include the SP linking the used database to that of the cooperating NP in case of bitstream open access. In the case of fiber open access, this would mean the interlinking of the NP-specific database with the database of the PIP.

By interlinking the databases, one removes the need for sending notifications. This is explained by the fact that interlinking databases reduces the information asymmetry. Furthermore, the link between both databases allows for the automatic generation of tasks. As the cost for notifications is rather low, a little less than 10 euros is saved on the churn of end users. This low value can be explained by the fact that there will still be a notification between the end users and the different providers. The end user still has to send a contract termination notification to either the service provider or the network provider.

Table 9: Churn costs for the different types of open access after the fifth optimization (costs in euros)

	Bitstream OA	Fiber OA, P2P	Fiber OA, P2MP
Original cost	423.8	394.8	386.3
Optimization: Standardization	307.2	278.8	270.3
Optimization: Pre-connected	307.2	269.7	262.9
Optimization: Grouped	307.2	256.1	262.9
Optimization: Administrative subscription	250.95	200.85	206.67
Optimization: Administrative termination	194.7	144.6	150.42
Optimization: Cross-company database	185.7	135.6	141.42

The notification cost can be further optimized by automating the notifications towards the end users. In this case, both a notification from the new and old provider can be automated, which will result in an additional saving of about € 18.

6.2.7 Optimization: Information gathering

The customer can search and/or verify information about different offers before entering into an agreement with a new supplier. To ensure fair and efficient competition for all suppliers in the end-user market it is important that customers are able to make fully informed switching decisions. Therefore, there should be at least one neutral price comparison tool available in each country. This tool should provide up to date and reliable information on available offers. In Europe, there are already similar tools available for electricity suppliers [84], [85].

This optimization reduces the costs for search and information. When a comparison tool is available, the consumer's buying decision process is simplified. Two main steps exist within this process. The first step is the information search for similar offers. The second step consists of comparing the alternatives to each other and making a decision. The availability of a price comparison tool eliminates the need for search and information. In case of an online available tool, one can simply use a web browser to access the tool. Hereby, the time spent at gathering information is significantly reduced as the information is readily available and only the price comparison will remain. Within [57] a relationship is studied between the internet experience and time spent searching for products online. Here, consumers spent on average about 15 minutes on online product searching when they have an internet experience of about four to six years. Taking into account the previously assumed value of 1.25 hours for search and information, containing both search and comparison, one arrives at a new search and information time spent by the end user of 1 hour.

Since the end user performs these actions in his free time, the cost assigned to the end user is zero. In order to investigate the impact of this optimization, one must assign an opportunity cost to the end user. Assigning an opportunity cost between € 10 and € 25 will result in a cost savings for the end user of about €2.5 to € 6.25.

6.2.8 Overview of all combined optimizations

The final segment of this chapter contains an overview of the combined optimizations. The optimizations include the introduction of standardized end user equipment, the introduction of pre-connected fibers at the central office and the different street cabinets, the simultaneously patching of multiple churning end users, administrative optimization, the use of a shared databases, and the introduction of a price comparison tool. In case an end user wants to churn service providers, the imposed optimizations introduce a cost reduction of about € 238 which equals a reduction of 56 %. For churn in a fiber open access scenario, the cost savings are about 65 % in case of a P2P topology and 63 % in case of a P2MP topology.

Table 10: evolution of churn costs for the different types of open access (costs in euros)

	Bitstream OA	Fiber, P2P	Fiber, P2MP
Original cost	423.8	394.8	386.3
Optimization: Standardization	307.2	278.8	270.3
Optimization: Pre-connected	307.2	269.7	262.9
Optimization: Grouped	307.2	256.1	262.9
Optimization: Administrative subscription	250.95	200.85	206.67
Optimization: Administrative termination	194.7	144.6	150.42
Optimization: Cross-company database	185.7	135.6	141.42
Optimization: Price comparison tool	185.7	135.6	141.42

When examining the cost assigned per cost category for an end user churning service providers (Figure 53), one notices an effect on all different categories. First, all equipment related costs are eliminated. This is attributable to the standardization of the RGW or ONT. Secondly, the supportive processes are completely eliminated. However, the effect on the operational process cost is minimal. This is because currently implemented optimizations do not target the operational costs such as the logical connection/disconnection and the set-up of the OVC. Investigation of the transaction costs shows that 75% of the bargaining costs can be removed through the optimization of the administrative subscription and termination.

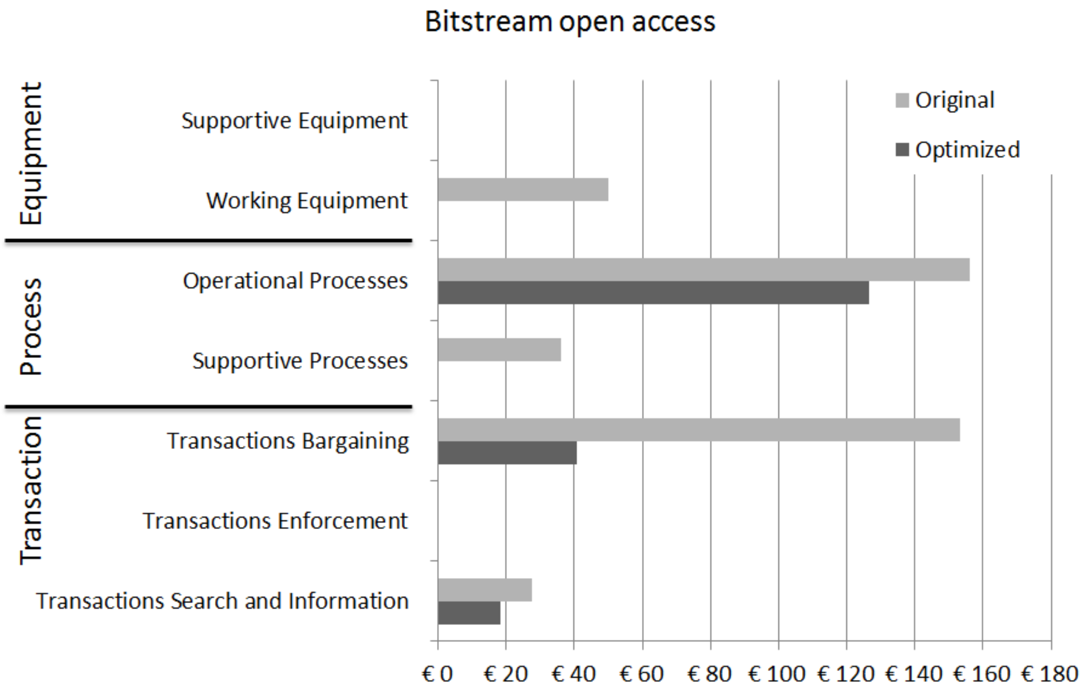

Figure 53: Comparison between the original and optimized churn for bitstream open access

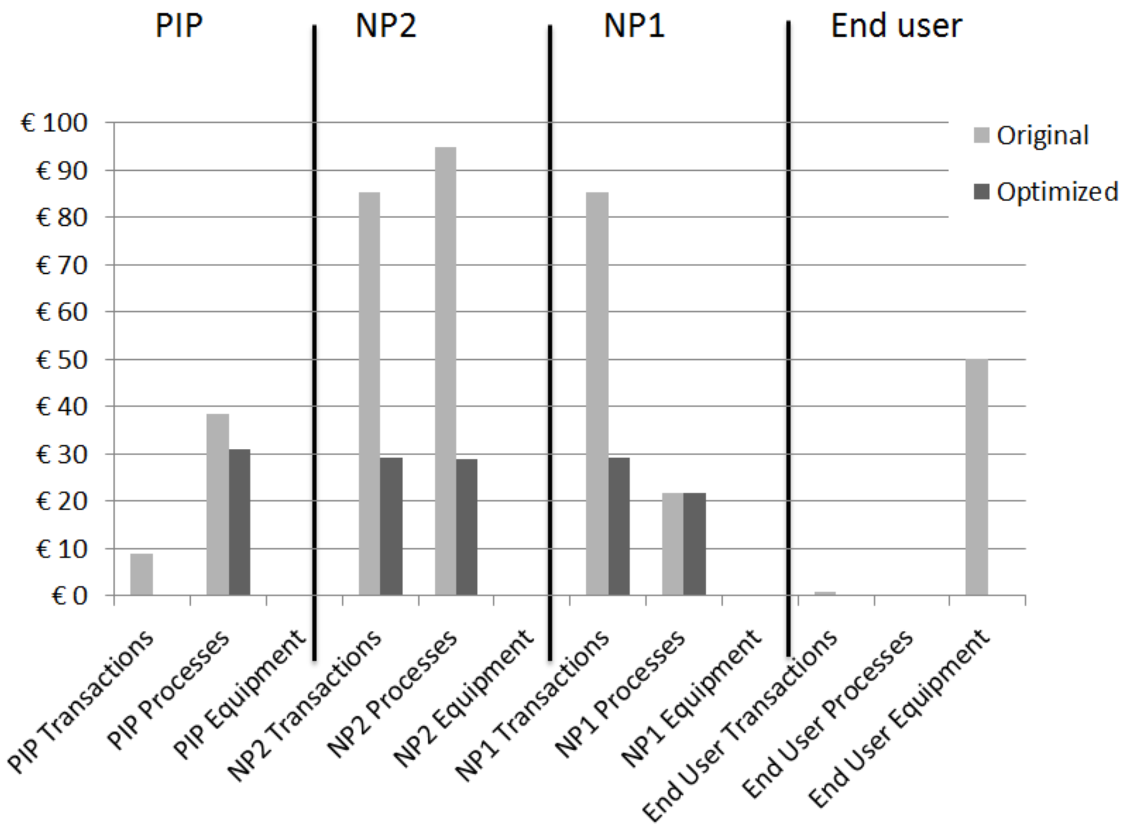

Figure 54: Comparison between the actors for the original and optimized costs of churn within a P2MP topology

When studying the effect of the proposed optimizations on the cost per actor in the case of an end user switching network providers, one notices an overall decrease in costs except for the process costs of the original NP. This occurs as the process costs for the original NP only include the logical disconnection of the end user. Furthermore, the effect of the proposed optimizations remains small for the process costs of the PIP. This is a consequence of the fact that the PIP will send out a technician to the street cabinet to reconnect the end user to the splitter of the right NP.

Finally, one can propose further optimizations for future work. The future optimizations should focus on the highest costs after the implemented optimization. These costs can be identified by performing a new Pareto analysis on the result of the combined optimization (Figure 55). The identified costs and hence, the optimizations for future work should tackle the logical connection and disconnection first.

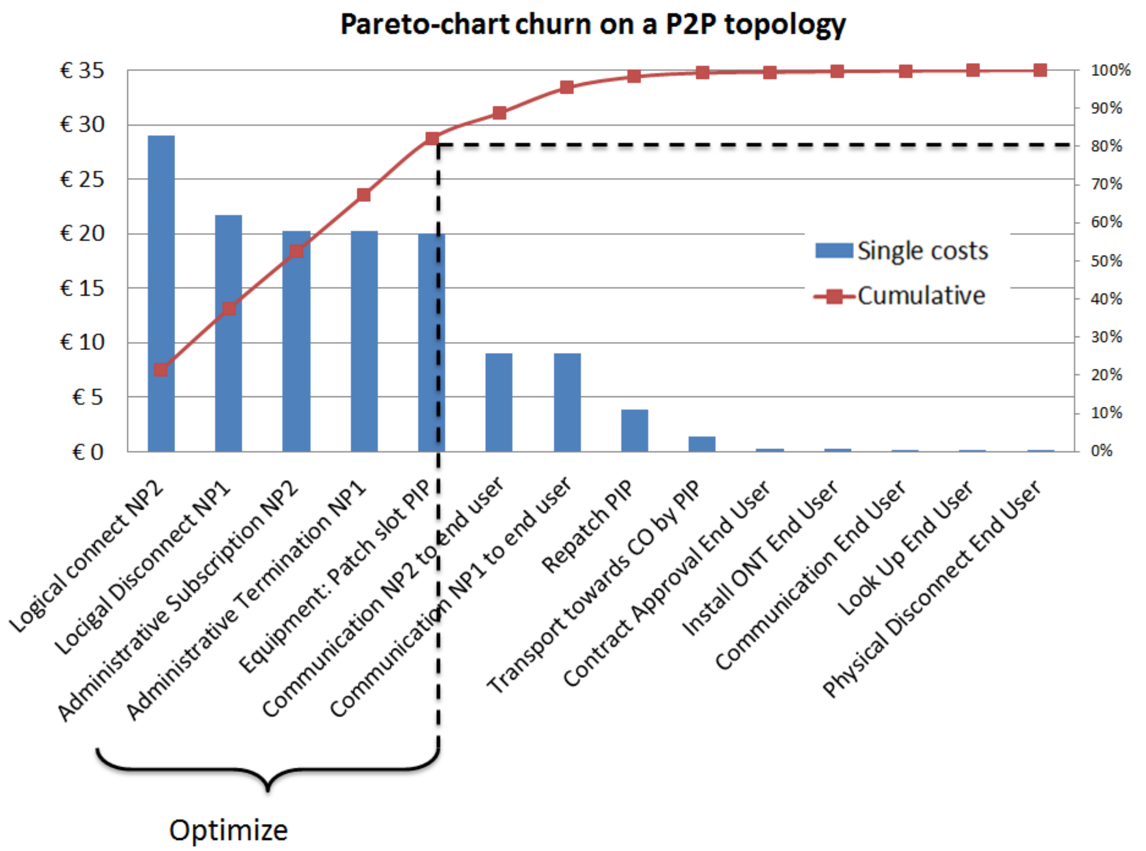

Figure 55: Pareto chart for churn over fiber open access and a P2P topology

6.3 Conclusion

Within this chapter, the optimization of the cost related to churn was investigated. In the first part of this chapter, a study was performed on theoretical optimization methodologies and opportunities. The optimizations focused on the different aspects of the churn cost: equipment, process, and transaction costs. A proposal for the optimization of processes included the introduction of lean manufacturing. Lean manufacturing is defined as the systematic approach of identifying and eliminating waste. Here, waste is defined as non-value adding activities. There are seven types of waste, namely: waiting, defects, overproduction, transportation, motion, inventory, and (over-)processing.

Next to the examination of process optimization, a study of minimizing transaction costs was performed. Here, the focus lies on the optimization of the different aspects of a single transaction. By decreasing the uncertainty and frequency, and increasing the asset specificity, the cost associated with transactions can be minimized.

The second part of this chapter focused on the implementation of the found techniques. Through the introduction of standardization, administrative simplification, shared databases, and pre-connectorized fibers, one can implement significant cost savings for the churn of an end user. In case of an end user switching service providers, the costs savings will account up to 56%. On the other hand, when an end user switches network provider, the proposed optimizations will result in a cost saving of about 65%.

Analysis of the cost assignment per category showed that most cost savings are made for equipment, supportive processes, and transactions. After the optimizations, the highest costs lie with the operational processes. This corresponds to the lean philosophy, where one eliminates waste and only keeps the value-adding activities. Finally, Pareto-analysis showed that there is still room for improvement. The highest costs, after optimization, were the logical connection and disconnection. In future work, these costs can be further optimized through automation of the processes.

Chapter 7 Conclusion and future work

Nowadays, competition will take on a dominant form because of the continual strive for perfection. Within competition, at least two parties reach for the same goal. Whether this goal is the highest revenue, largest customer base or even the best service, competitors will strive to be the best. As a result, competition will have a positive effect on the different aspects of the services offered. Innovative and new products/services will enter the market, the quality of existing services will increase, the variety of services will increase, and prices will decrease.

Next to these well-known benefits, competition allows customers to change their provider when they are dissatisfied with their current service. Within the telecommunications sector, this process is known as churn. Even though churn is an inescapable part of competition, it is rather expensive. This comes from the fact that the cost for churn is threefold. First, churn corresponds to a loss in revenue for the original company, either through the loss of customers or through lowering the selling price of the service in order to remain competitive. Second, costs are related to the efforts concerning the reacquisition of lost customers or the prevention and prediction of customer churn. Third, the churn process itself will have a specific cost. It is this cost that was examined throughout this work.

Within this work, the impact of churn was investigated on a new access network. This new access network replaces the current copper and coaxial cables by optical fibers. Out of the different scenarios, a FTTH network came out on top as it allows for high bandwidths over large distances. Even though a FTTH network is the best solution for higher bandwidths, the initial cost for deploying this FTTH network is very high. This high investment cost will not be covered by one actor but shared between multiple actors. These actors are the physical infrastructure provider, the network provider, and the service provider. Furthermore, competition and collaboration will arise between the different actors. The competition and collaboration within the network is realized through the offering of open access. Within this work, two types of open access were studied: fiber open access and bitstream open access.

In order to study the effects of churn within the access network, the technical realization of the network and the offering of open access were examined. The two possible topologies to realize this network are a point-to-point (P2P) and a point-to-multipoint (P2MP) topology. Within a P2P topology, a dedicated fiber is assigned to each end user. On the other hand, a P2MP topology uses fibers that are shared between multiple end users. Next to the investigation of the different topologies, a study was made between the different components of an access network. After the examination of these components, the different types of open access were considered. Two types of open access were explored. The first type of open access is fiber open access and allows the connection of multiple network providers on top of a single physical infrastructure provider. Furthermore, a distinction is made between a P2P and a P2MP topology. The second type is bitstream open access, which in contrast to fiber open access, can be offered independent of the used topology and technology.

Next, an investigation was performed on the effective churn procedures. Within these procedures, the incurred churn costs are identified and classified. In a first step, a cost breakdown structure was defined to classify the identified costs. This cost breakdown structure is based on a tree structure, which contains three main branches: equipment costs, process costs, and transaction costs. The second step is the investigation of the different churn procedures. For each of the studied types of churn, i.e. an end user switching network providers and an end user switching service providers, a qualitative description was given. This description contains a detailed summary of each process step and a formula for the cost calculation based on the identified cost drivers.

Once the identification of the cost drivers was performed, the cost drivers were used to model the cost for churning an end user. The defined model operates as follows: depending on the defined type of churn, the model would acquire the corresponding input values and procedure list; calculate the cost for the procedure based on the defined cost functions for the defined type of churn; and return the obtained costs for the churn of an end user.

A first result of the model considered an end user churning service providers (bitstream open access). Here, a total cost for the churn of an end user of about € 420 was found in case of a service provider installation and a total cost of about € 360 for an end user installation. The majority of this cost was attributed to transaction and process costs taking up about 90% of the total cost. An analysis of the cost assignment per actor showed that the new service provider carries 40% of the cost for churn. This cost is evenly distributed between transactions and processes. The second and third highest costs are assigned to the old service provider (25%) and the network provider (20%). Even though the end user will perform processes and transactions, these costs are not shown since the hourly labor cost for the end user was chosen to be zero. In order to study the effect of transactions and processes on the end user, an opportunity cost was assigned. This assignment showed that the transactions will have a significant impact on the end user but the process cost remains negligible.

A second result of the model considered the cost for an end user churning network providers (fiber open access). Here, two scenarios were analyzed based on the used network topology. These topologies are a P2P and a P2MP topology. The cost for churn in both scenarios was about € 390. Similar to an end user churning service providers, about 85% of the churning cost is assigned to transactions and processes. Analysis of the cost assignment per actor showed that the majority of costs is assigned to the new network provider followed by the old network provider. Furthermore, the analysis showed that the only difference between the P2MP and the P2P topology are attributed to the physical infrastructure provider while the cost for both network providers and the end user remains equal. Finally, Pareto-analysis showed that the administrative cost for subscription and termination should be among the first to optimize.

After the analysis of the cost for churn, different optimizations were examined. These optimizations are based on the different nature of the incurred costs and optimize either the equipment, process or transaction costs. As a result, each optimization is used to impact one cost category. Optimization of the equipment is based on standardization. Lean manufacturing will lie on the basis for process optimization while automation and reducing information asymmetry are applied to transaction costs. Furthermore, each optimization builds on the previous optimization and therefore corresponds to the aggregation of all previous optimization.

The first optimization related to the use of standardized end user equipment. This optimization reduced the equipment, installation, and transportation costs. The second optimization included the introduction of pre-connectorized fibers, which impacts the process costs. However, this optimization was only applicable to an end user churning network providers. The next optimization considered the simplification and automating of the administrative procedure to tackle the high transaction costs. The final two optimizations tackled the search and information costs. By introducing a cross company database between cooperating actors, the cost for communication between actors can be reduced. Furthermore, the introduction of a neutral price comparison tool for end users reduced the search time for end users significantly and only the comparison of different orders remains.

The combined result of all proposed optimizations results in a decrease of more than half in case of an end user churning service providers (from about € 420 to about € 185) and about 65 % in case of an end user churning network providers. These optimizations are the result of the elimination of equipment costs through the introduction of standardization, the decrease of transaction costs by 75% as the administrative procedures are automated and simplified and the significant reduction of supportive processes as the amount of needed transportation is greatly reduced.

Future work can complement different aspects of this work. First, the existing model could be extended for an end user churning service providers. For an end user churning service providers only a distinction was made between an end user installation and a provider installation. This distinction can be further examined by introducing diversity in offered service. Some services will be offered over the top and will not require the use of an RGW. Services can differ from end user to end user or be the same for all end users, which might have implications on processes during the churn procedure.

Furthermore, the physical infrastructure provider might offer wavelength open access instead of fiber open access. In this case, the churn procedure for an end user switching a network provider must be extended with the introduction of wavelength open access. Churn within wavelength open access should be examined both with a qualitative and a quantitative description.

The current optimizations can be extended. A Pareto-analysis after the proposed optimization showed that the optimization of the logical connection and disconnection should be the first to tackle when implementing further optimizations.

Next, the examination of the churn procedure only included voluntary churn by an end user. One could investigate the effect on the cost for churn in case there is involuntary churn. Here, the contract is terminated by the old provider and an investigation should research the impact of terminating a service or the forced termination of one end user.

Churn can also be investigated from the point of the end users. Here, the end users want the switch between providers to be as cheap and simple as can be. A solution to this is assigning all administrative operations to the new provider [86]. This means that the end user only has to contact the new provider. This new provider will than take care of the termination of the old contract, etc. By introducing this separate procedure, the operators will spent more efforts in simplifying the administrative processes further.

References

[1] Digital Agenda for Europe, A Europe 2020 Initiative, available at http://ec.europa.eu/digital-agenda/digital-agenda-europe

[2] MATTISON, Rob. *The telco churn management handbook*. Lulu. com, 2006

[3] WEI, Chih-Ping, et al. Turning telecommunications call details to churn prediction: a data mining approach. *Expert systems with applications*, 2002, 23.2: 103-112.

[4] AHN, Jae-Hyeon; HAN, Sang-Pil; LEE, Yung-Seop. Customer churn analysis: Churn determinants and mediation effects of partial defection in the Korean mobile telecommunications service industry. *Telecommunications Policy*, 2006, 30.10: 552-568.

[5] HUNG, Shin-Yuan; YEN, David C.; WANG, Hsiu-Yu. Applying data mining to telecom churn management. *Expert Systems with Applications*, 2006, 31.3: 515-524.

[6] MADDEN, Gary; SAVAGE, Scott J.; COBLE-NEAL, Grant. Subscriber churn in the Australian ISP market. *Information Economics and Policy*, 1999, 11.2: 195-207.

[7] Preventing 'customer churn', Why B2B businesses switch suppliers and the industries most at risk from customer defection, Pitney Bowes, available at http://pressroom.pitneybowes.co.uk/download/225

[8] Consumers' views on switching service providers, a survey requested by DG SANCO, January 2009, available at http://ec.europa.eu/public_opinion/flash/fl_243_sum_en.pdf

[9] DASGUPTA, Koustuv, et al. Social ties and their relevance to churn in mobile telecom networks. In: *Proceedings of the 11th international conference on Extending database technology: Advances in database technology*. ACM, 2008. p. 668-677.

[10] KATZ, Michael L.; SHAPIRO, Carl. Systems competition and network effects. *The Journal of Economic Perspectives*, 1994, 93-115.

[11] LEVITT, Theodore, et al. *Exploit the product life cycle*. Graduate School of Business Administration, Harvard University, 1965.

[12] 4 Stages of Small business Product Life Cycle, available at http://www.businesssetfree.com/small-business-product-life-cycle/

[13] LEE, Sang-Gun, et al. A model for analyzing churn effect in saturated markets. *Industrial Management & Data Systems*, 2011, 111.7: 1024-1038.

[14] Definition: Incumbent, available at http://moneyterms.co.uk/incumbent-telco/

[15] NEIL, Martin; LITTLEWOOD, Bev; FENTON, Norman. Applying Bayesian belief networks to system dependability assessment. In: *Safety-Critical Systems: The Convergence of High Tech and Human Factors*. Springer London, 1996. p. 71-94.

[16] OASE, "Value network evaluation". Project deliverable (D6.3). Available: http://www.ict-oase.eu/.

[17] RICHELDI, Marco; PERRUCCI, Alessandro. Churn analysis case study. *Deliverable D17*, 2002, 2.

[18] Belgian telecom wet, information available at http://www.belgium.be/nl/nieuws/2012/news_telecomwet.jsp

[19] Belgian telecom, frequently asked questions, available at http://economie.fgov.be/nl/ondernemingen/informatiemaatschappij/Telecommunicatie/FAQ/

[20] Directive 2002/22/EC of the European parliament and of the council of 7 march 2002 on universal service and user's rights relating to electronic communications networks and services as amended by Directive 2009/136/EC(**), available at https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/Copy%20of%20Regulatory%20Framework%20for%20Electonic%20Communications%202013%20NO%20CROPS.pdf

[21] European Commission, Telecoms Rules, available at http://ec.europa.eu/digital-agenda/en/telecoms-rules

[22] European Commission, 2014 Report on Implementation of the EU regulatory framework for electronic communications, available at https://ec.europa.eu/digital-agenda/en/news/2014-report-implementation-eu-regulatory-framework-electronic-communications

[23] BoR (10)08, Body of European regulators for Electronic Communications (BEREC), Next Generation Access – Implementation Issues and Wholesale Products, 15 March 2010

[24] The Fiber Optic Association, Guide To Fiber Optics & Premises Cabling, available at http://www.thefoa.org/tech/ref/appln/FTTHarch.html,

[25] ICT Regulation Toolkit, Cost Analysis for FTTH, available at http://www.ictregulationtoolkit.org/en/toolkit/notes/PracticeNote/2974

[26] VAN DER WEE, Marlies, et al. Evaluation of the Techno-Economic Viability of Point-to-Point Dark Fiber Access Infrastructure in Europe. *Journal of Optical Communications and Networking*, 2014, 6.3: 238-249.

[27] VAN DER WEE, Marlies, et al. Techno-Economic Evaluation of FTTH Migration for a Network Provider: Comparison of NG-AON and TWDM-PON. In: *Asia Communications and Photonics Conference*. Optical Society of America, 2013. p. AW3I. 3.

[28] CASIER, Koen, et al. Improving the FTTH business case benefits of an holistic approach. *JOURNAL OF THE INSTITUTE OF TELECOMMUNICATIONS PROFESSIONALS*, 2011, 5.1: 46-53.

[29] VAN DER WEE, Marlies, et al. Making a success of FTTH learning from case studies in Europe. *Journal of the Institute of Telecommunications Professionals*, 2011, 5.4: 22-31.

[30] FORZATI, Marco; LARSEN, Claus Popp; MATTSSON, Crister. Open access networks, the Swedish experience. In: *Transparent Optical Networks (ICTON), 2010 12th International Conference on*. IEEE, 2010. p. 1-4.

[31]The Supreme Council of Information and Communication Technology, Regulatory Framework for Open Access to Megaprojects, Consultation document, available at http://www.ictqatar.qa/en/documents/document/regulatory-framework-open-access-megaprojects-public-consultation

[32] LIMBACH, Felix, et al. A typology of cooperation strategies in the telecommunication industry: An exploratory analysis and theoretical foundations. 2011.

[33] DIXIT, Abhishek, et al. Fiber and wavelength open access in WDM and TWDM passive optical networks. *Network, IEEE*, 2014, 28.6: 74-82.

[34]Keymile White Paper: Open Access Demands on FTTx Network Technology, available at http://www.keymile.com/en/applications/fttx

[35]VERBRUGGE, Sofie, et al. FTTH deployment and its impact on network maintenance and repair costs. In: *Transparent Optical Networks, 2008. ICTON 2008. 10th Anniversary International Conference on*. IEEE, 2008. p. 2-5.

[36] Vodafone, Key Principles for Wholesale Access over Next Generation Fixed Networks, The Policy Paper Series , available at http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/nga_wholesale_access.pdf

[37] LIMBACH, Felix; ZARNEKOW, Ruediger; DÜSER, Michael. Co-opetition in next-generation access provisioning: An analysis of the German broadband market. 2012.

[38] VAN DER WEE, Marlies, et al. A modular and hierarchically structured techno-economic model for FTTH deployments Comparison of technology and equipment placement as function of population density and number of flexibility points. In: *Optical Network Design and Modeling (ONDM), 2012 16th International Conference on*. IEEE, 2012. p. 1-6.

[39] HOEMING, Stephan et al. WIK consult report: Architectures and competitive models in fibre networks , *Study for Vodafone*, December 2010, available at http://www.vodafone.com/content/dam/vodafone/about/public_policy/position_papers/vodafone_report_final_wkconsult.pdf

[40] TERRAIN, Project deliverable D4.1. Technology Roadmap and Migration Strategies, internal reference

[41] LAM, Cedric F. FTTH Look Ahead: Technologies and Architectures. In: *Proc. 36th European Conf. on Optical Communications (ECOC'10)*. 2010. p. 1-18.

[42] FTTH infrastructure, Components and Deployment Methods, Network Infrastructure Committee, Issued for Barcelona 2007

[43] D&O committee, FTTH Handbook Edition 2, 6 February 2012, available at http://www.ftthcouncilmena.org/

[44] VAN DER WEE, Marlies, et al. Techno-economic evaluation of open access on FTTH networks: a trade-off question. 2014, internal reference

[45] The Fiber Optic Association, Guide To Fiber Optics & Premises Cabling, Fiber Optic Splicing and Termination, available at http://www.thefoa.org/tech/ref/OSP/term.html

[46] Ruderman, K. Operator agreements catalyze FTTH builds in France's low-density areas. Light Wave Online, 26 January 2012.

[47] Metro Ethernet Forum (MEF), Technical Specification MEF 26.1, External Network Network Interface (ENNI) – Phase 2, available at https://wiki.metroethernetforum.com/display/CESG/MEF+26.1+Reference+Page

[48] Metro Ethernet Forum (MEF), Technical Specification MEF 10.2, Ethernet Services Attributes Phase 2, available at https://wiki.metroethernetforum.com/display/CESG/MEF+26.1+Reference+Page

[49] WILLIAMSON, Oliver E. The economics of organization: the transaction cost approach. *American journal of sociology*, 1981, 548-577.

[50] Object Management Group, Business Process Management Initiative, available at http://www.bpmn.org/

[51] Object Management Group, Business Process Management Initiative, available http://www.bpmn.info/

[52] KAPLAN, Robert S.; ANDERSON, Steven R. Time-driven activity-based costing. Harvard business review, 2004, 82.11: 131-140.

[53] The Consumer Factor, The 5 stages of Consumer Buying Decision Process, available at http://theconsumerfactor.com/en/5-stages-consumer-buying-decision-process/

[54] Java documentation: Class HashMap, available at http://docs.oracle.com/javase/7/docs/api/java/util/HashMap.html

[55] Object Management Group, Unified Modeling Language Resource Page, available at http://www.uml.org/

[56] OASE, "Techno-economic assessment studies". Project deliverable (D5.3). Available: http://www.ict-oase.eu/

[57] WARD, Michael R.; LEE, Michael J. Internet shopping, consumer search and product branding. Journal of product & brand management, 2000, 9.1: 6-20.

[58] PARK, C. Whan; LESSIG, V. Parker. Familiarity and its impact on consumer decision biases and heuristics. *Journal of consumer research*, 1981, 223-231.

[59] VERBRUGGE, Sofie, et al. Impact of resilience strategies on capital and operational expenditures. *Proceedings of ITG Tagung Photonical Networks*, 2005, 109-116.

[60] OASE, "Process modeling and first version of TCO evaluation tool". Project deliverable (D5.2). Available: http://www.ict-oase.eu/.

[61] KARUPPUSAMI, G.; GANDHINATHAN, R. Pareto analysis of critical success factors of total quality management: A literature review and analysis. *The TQM magazine*, 2006, 18.4: 372-385.

[62] CASIER, Koen, et al. On the costs of operating a next-generation access network. In: *Proceedings of CTTE2008, the 7th Conference Telecom, internet and media Techno-Economics.* 2008.

[63] DB marketing, The lifetime value of a Land Line Phone Subscriber, available at http://www.dbmarketing.com/wp-content/uploads/2010/03/The-lifetime-value-of-a-Land-Line-Phone-Subscriber.pdf

[64] Nexus Telecom, Business Case – Reduce Customer churn , available at http://www.nexustelecom.com/solutions/reduce_churn/index.php

[65] KRAFFT, Jackie; SALIES, Evens. The diffusion of ADSL and costs of switching Internet providers in the broadband industry: *Evidence from the French case. Research Policy*, 2008, 37.4: 706-719.

[66] Statista, Proportion of fixed broadband users who switched provider in the last twelve months, available at http://www.statista.com/statistics/274211/fixed-broadband-users-who-switched-provider-in-the-last-12-months/

[67] CASIER, Koen, et al. Economics of FTTH: a comparative study between active and passive optical networks. In: *48th FITCE Congress*. FITCE (Forum for European ICT Professionals), 2009. p. 35-39.

[68] Fast Net News, Fiber Economics – Quick and Dirty, available at http://fastnetnews.com/fiber-news/175-d/4835-fiber-economics-quick-and-dirty

[69] Wikinvest, Deutsche Telekom CPGA and CCPU, available at http://www.wikinvest.com/stock/Deutsche_Telekom_AG_%28DT%29/Cpga_Ccpu

[70] British Telecom, Contracts and Early Termination charges, available at http://www.productsandservices.bt.com/consumer/terms/contracts-early-termination.html

[71] Proximus, Proximus Internet Prijzen, available at www.proximus.be

[72] Telenet, Jaarverslag 2012, available at http://jaarverslag2012.telenet.be/ressources/en/pdf/financial_report_2012.pdf

[72] SCHNEIR, Juan Rendon; XIONG, Yupeng. Cost analysis of network sharing in FTTH/PONs. *Communications Magazine, IEEE*, 2014, 52.8: 126-134.

[74] BHAMU, Jaiprakash; SANGWAN, Kuldip Singh. Lean Manufacturing: Literature review and research issues. *International Journal of Operations & Production Management*, 2014, 34.7: 3-3.

[75] KILPATRICK, Jerry. Lean principles. *Utah Manufacturing Extension Partnership*, 2003, 1-5.

[76] SARKAR, Debashis. *Lean for Service Organizations and Offices*. Pearson Education India, 2008.

[77] ROBERTSON, Michael; JONES, Carole. Application of lean production and agile manufacturing concepts in a telecommunications environment, *International Journal of Agile Management Systems*, 1999, 1.1: 14-17.

[78] HICKS, B. J. Lean information management: Understanding and eliminating waste. *International journal of information management*, 2007, 27.4: 233-249.

[79] DYER, Jeffrey. Effective interfirm collaboration: how firms minimize transaction costs and maximize transaction value. 2002.

[80] DIN German Institute for Standardization, Economic benefits of standardization, Summary of results, available at http://www.din.de/sixcms_upload/media/2896/economic_benefits_standardization.pdf

[81] International Organization for Standardization, How does ISO develop standards, available at http://www.iso.org/iso/home/standards_development.htm

[82] DEUTSCH, DR BERNHARD; WHITMAN, ROBERT; MAZZALI, DR CLAUDIO. Optimization of FTTH passive optical networks continues. 2005.

[83] http://telenet.be/nl/internet/basic-internet

[84] Mijn energie, Energieprijzen vergelijken, available at http://www.mijnenergie.be/energieleveranciers-vergelijken-

[85] Nordic Energy Regulators, Harmonised model for supplier switching, April 2013, available at http://www.nordicenergyregulators.org/wp-content/uploads/2013/02/Future-model-for-switching.pdf

[86] Het Nieuwsblad, Switch digitale televise wordt eenvoudiger, available at http://www.nieuwsblad.be/cnt/dmf20141217_01434267

Appendix A: java source code for the model

The model used in this work was implemented based on the object oriented programming language Java. The source code of the model is made available at http://teintra.intec.ugent.be/Student_area/Student_pages/Nick_Muylaert.
On this page you can the zip file Model_Nick_Muylaert.zip that contains the source code.

Furthermore, the code is accessible through SVN and available at https://svn.intec.ugent.be/svn/thesisnmuylaert/OPEN ACCESS.
All the source code is grouped within the package churn

Appendix B: Interview with a Proximus sales employee

Location: Proximus center Aalst
Grote Markt 25
9300 Aalst

Date: 10 januari 2015

Interviewee: A Proximus sales manager (wishes to remain anonymous)

The start of this interview was given by an introduction to Proximus. Proximus is a telecommunications provider that recently changed its name (formerly known as Belgacom). It is an autonomous government company and has products in telecommunications, the mobile phone sector, internet offers, and digital television. After a short introduction to Proximus, the sales manager showed operated the computer program and the features it provides. It is an integrated software system that has access to every aspect within Proximus. This includes the available products (both software and hardware), customer information, accounting, catalogues, and the sales application.

When asked about the procedures for sales, the employee gives the notification that these procedures are classified and should not be disclosed to outsiders. However, when asked about a general outline of these procedures the following guideline is given. The manager indicates that a classification is made between new customers or connected customers. When asked about churning customers, the manager responds that these customers are treated as new customers without distinction in procedures.

First and foremost, the sales manager and customer determine the specific needs of the customer. What products does the customer already have and which products/pack does the customer want. Once these points are established, the sales manager will check what is possible. This includes an examination of the current state of the customer's connection, if trenching is needed, etc. After passing this section, the sales manager will open up S@lto (Figure 56) and start the ordering procedure, which consists of four steps. Each step is automatically checked and must be successfully passed before one can go to the next.

Step 1: entering information.
The sales manager will enter the personal information of the end user. This includes the full name, address, birthday, etc. of the end user. If the customer is already connected, this information can be found by entering the customer's phone number. Once this information is filled in, the wanted products are selected and added to the customer's profile as well as a start date of the contract. Furthermore, if a technician must come by, a date is selected and agreed upon. The cost for this technician is fixed at € 75 euros, independent of the distance, type of installation, etc.

Step2: validation of the ordered products.
Once the information is entered in the database, a validation is performed. Here, the system

checks if the products are available the customer and all entered information is correct. For example: a home user can't order a business offer, is the appointment with the technician before the start of the contract? If a customer wants to keep his current phone number, does he include the waiting period of 2 business days for the transfer? If the system detects faults or inconsistencies, adjustments can be made.

Step3: overview of the order.
If the validation is performed, an overview is generated. The sales manager will revise all changes with the customer. If the customer wants to adjust any offers, the manager can go back to the validation step.

Step4: submitting of the order for processing.
Once the customer is satisfied, the order is submitted for automatic processing and the procedure is finished.

When a customer wants to terminate his contract or specific parts of his contract, the same steps are followed within S@lto. The customer's information is brought up and the contracts will be marked as closed. The sales manager and customer agree upon an end date of the contract and one can move on to the validation step. Here, the customer's account is checked for fines, and the return of equipment is covered. Since the customer rents the equipment, it must be returned. The serial number is scanned as the equipment is linked to the customer. The manager also mentions that the sales value of a decoder is at € 125 but is rented for a cost of 0 €, while a B-box has a sales value of € 99. A final step is the reckoning of acquired hardware for the resting value as some formulas give hardware for cheap prices. After the validation step, an overview is generated and the order submitted.

When asked about the duration of these procedures, the sales manager replies with an average duration of about 15 minutes. However, the manager also remarked that this could be faster as the validation step takes the longest. As the system validates the order, certain parts of database must be consulted. Since all aspects are integrated into this database, this process is slow. Iteration of this step, when inconsistencies appear will further prolong the procedure.

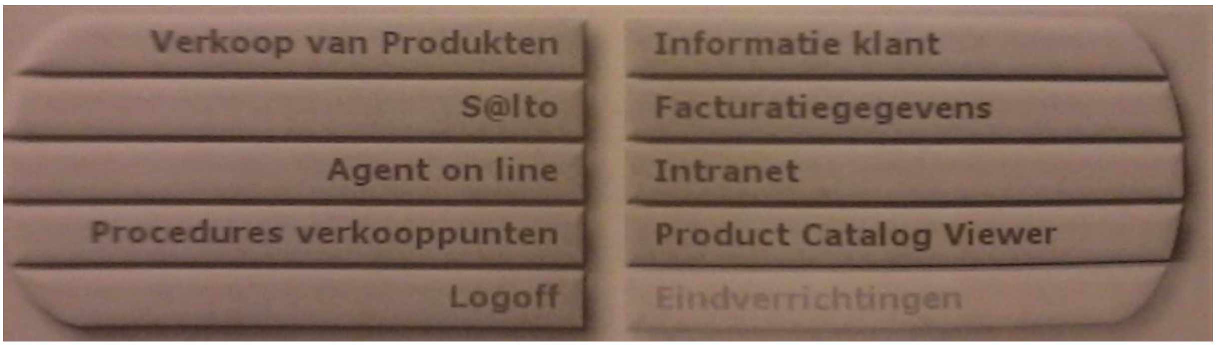

Figure 56: Overview of the start screen sales person Proximus