Value creation through network infrastructure automation

The Software-Defined Networking Technology and its business model from the IT service provider's perspective

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Delft University of Technology &
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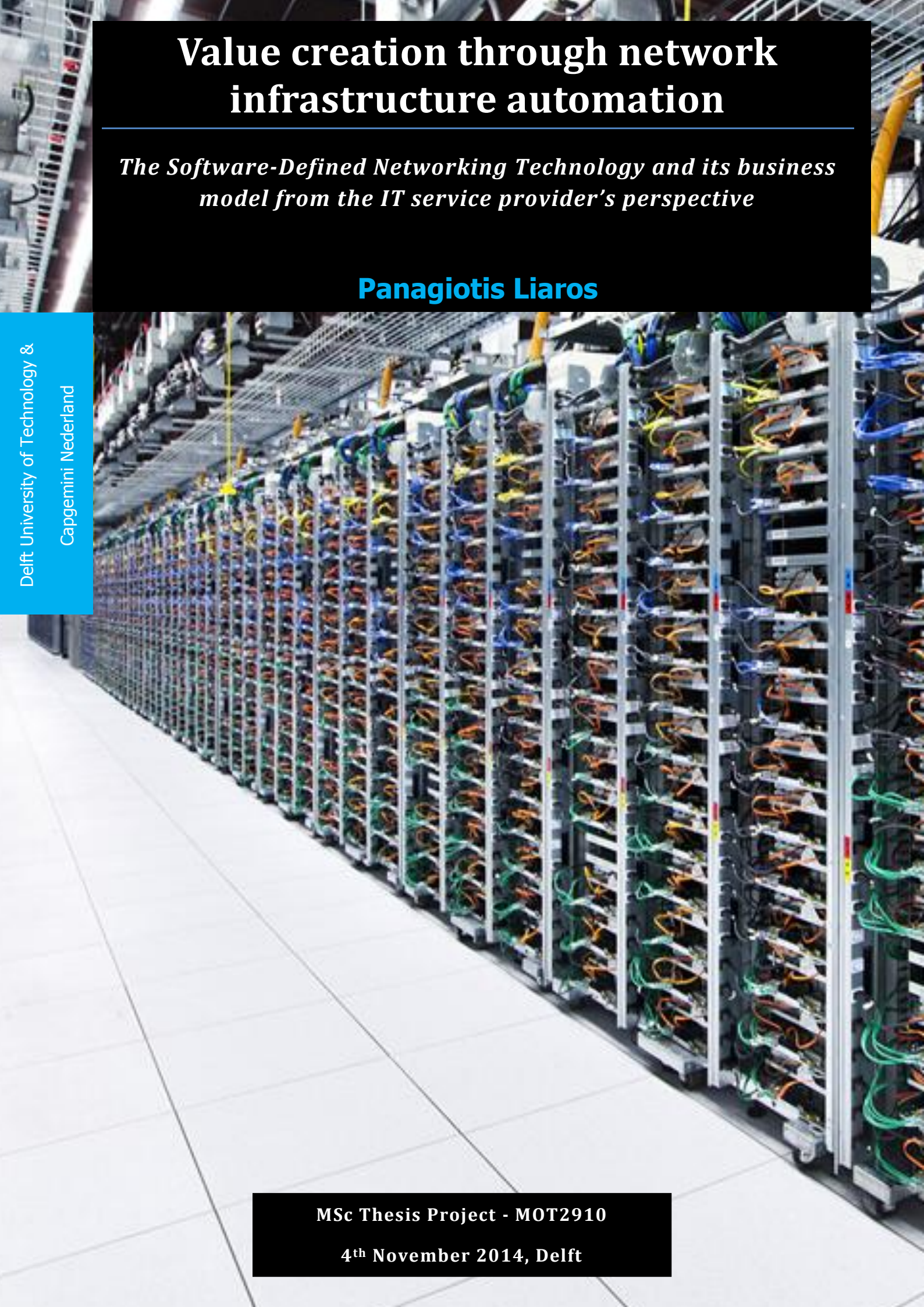

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By

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Executive summary

Our research is exploring how the computer network technology of Software-Defined Networking (SDN) can benefit an IT service provider. SDN is a novel technology that is capable of managing a whole network based on a single centralized entity. As a result an SDN enabled network becomes more flexible, automatable and programmable to satisfy users' needs. SDN with its automation features can enhance cloud services, and mainly the well-known Infrastructure as a Service (IaaS), as it can significantly reduce the services' delivery time and the costs for their provisioning.

More specifically, this thesis emphasizes on how the IT service provider's datacenter services can be improved both for its own benefit and of course for the benefit of its customers as well. Our approach for the exploration and exploitation of the novel technology, is the design of a business model enabled by SDN technology. Primary stakeholder and user of the business model is the IT service provider.

Additionally, we have to specify that this research is based on a single case study that is executed in collaboration with the Dutch branch of Capgemini. For the completion of our research we are making extensive literature review and interviews with experts of the field.

In the next lines of this summary we are going to briefly mention the contents of each chapter as well as our findings, conclusions and recommendations for each one of them. The maser thesis consists of six chapters, which are interconnected as a logical continuation of each other. More specifically:

Chapter 1 – Introduction. This is the chapter that is making a general reference to the contents of the master thesis, the issue stakeholder, the research objectives, and research questions. Issue stakeholder is the IT service provider, and our three research objectives are: "the identification of the current state and future trends of the SDN technology both in the market and the academia", "the identification of the business model framework that supports the case of the SDN technology adoption from an IT service provider" and "the design of a business model for delivery of SDN enabled services". These three research objectives are translated to three relevant research questions. All three research questions are giving answer to the main research question.

Chapter 2 – State of the art of SDN - Current status and future trends. The second chapter is giving answer to the first research question: "What is the state of the art of SDN?". It is related with the state of the art of SDN and its future trends. A brief summarized answer would be that SDN is currently still in its early adoption phase and OpenFlow is the dominant enabling protocol. Moreover, there are many different SDN controllers in the market and much more are the nonproprietary projects that big established infrastructure vendors support. Use cases of SDN are focusing on: network management and availability, security assurance and innovative wireless implementations. The diffusion of SDN technology for the entire market is yet to come. The future of the SDN technology is forecasted to be full of new developments that will be open source oriented. The SDN market is constantly growing and the academia is eager to keep exploring and exploiting the domain.

The outcomes of chapter two are taken in consideration for the design of the business model in chapter five.

Chapter 3 – Business Model Literature Review. In the third chapter of the master thesis is given answer to the second research question: "Which business model framework best supports the design

of an SDN business model?". For this answer an extensive comparison of three different business model frameworks is made. The STOF, VISOR and Canvas frameworks are compared and as the best fitting framework to the case of SDN is chosen to be the STOF framework.

Chapter 4 – Research design methodology. In the fourth chapter the research design of the thesis is made explicit. Through the chapter is analyzed the research design methodology, the data collection methodology and the way that the chosen business model framework is used. We are making use of the design science research of (Vaishnavi & Kuechler, 2007) and the design cycle for the design oriented researches of (Verschuren & Hartog, 2005). Plus we are extracting all the necessary data for our research through interviews with experts.

Chapter 5 – Business model design. The fifth chapter is the initiation of the second part of the thesis where the business model is designed and the third and last research question is answered: "Based on the selected business model framework, how does a viable business model that integrates SDN technology in an IT service provider's datacenter infrastructure, looks like?".

Chapter 6 – Discussion and Conclusions. Conclusions, limitations as well as future research, in addition with some recommendations and reflection of the whole thesis, are included in this chapter. Much more the main research question is answered as well.

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1 Chapter 1 – Introduction

1.1 Introduction

The present master thesis is exploring how the computer network technology of Software-Defined Networking (SDN) can benefit an IT service provider. SDN is a novel technology that is capable of managing a whole network based on a single centralized entity. As a result an SDN enabled network becomes more flexible, automatable and programmable to satisfy users' needs (ONF, 2014). SDN with its automation features can enhance cloud services, and mainly the well-known Infrastructure as a Service (IaaS), as it can significantly reduce the services' delivery time and the costs for their provisioning.

More specifically, this thesis emphasizes on how the IT service provider's datacenter services can be improved both for its own benefit and of course for the benefit of its customers as well. Our approach for the exploration of the novel technology, is the design of a business model enabled by SDN technology. Primary stakeholder and user of the business model is the IT service provider. Additionally, it is expected that the academic research related to valorization of SDN technology will be advanced as well. The research is based on literature review and interviews with experts of the field.

1.2 Problem description

1.2.1 Practical view

The problem that this master thesis explores is the design of a business model based on SDN that supports adoption of the technology by a large IT service provider. The business model helps to explore the added value that the IT service provider and its customers receive from the SDN implementation. Additionally, it explores the specific enabling components of SDN technology that are needed and the stakeholders that are required for the seamless provision of SDN based services.

We aim to design a business model for the Software-Defined Networking (SDN) technology that promises to revolutionize the telecommunications industry and commoditize the network infrastructure (Carr, 2003). The business model design takes place from the perspective of an IT service provider. The SDN technology is till now known to be adopted by some big multinational companies that are trying to gain a competitive advantage, as well as research organizations and universities that aim to advance the field of SDN itself .

The major adding value feature of SDN compared to the existing technologies is its ability to provision services much faster due to the automation of processes that brings. So projects that till now took days to be implemented, are now with the SDN technology completed in only some hours. This is having major advantages that are translated in cost reduction and flexible service provisioning. This fast service provision is a "chain reaction" for all the stakeholders of the value chain, i.e. if the clients of the IT service provider are served faster, then the clients of their own will be served faster

as well (Porter, 2001). And of course this effect goes on for the rest of the value chain, which can be beneficial in multiple levels of the industry and maybe even for the society.

Anyhow, SDN has not achieved to cross the "chasm", get popular and trusted by many large enterprise customers yet. But the growing interest is making many of the computer network market's stakeholders, among them the IT service providers, eager to explore the domain of SDN. Either to seize the advantages of the technology themselves, to create organizational knowledge and start providing the technology as a service to third parties. Especially the latter case is likely to become popular when SDN will be more mature, and customers will have to take less risks when making use of it.

Last but not least, this master thesis is executed in collaboration with the Dutch branch of Capgemini. Capgemini is a multinational IT service provider company with presence in more than 40 countries around the world. Capgemini Nederland has contracts with big Dutch companies, such as Kadaster and Eneco, as well as the Dutch government and some Dutch universities (Capgemini, 2013).

1.2.2 Academic view

Due to the novelty of SDN, there is scarce academic literature available that explores the business model aspects of SDN technology. So our business model might be the first one to explore this scientific domain. This master thesis is advancing the domain and partially fills knowledge gaps in literature on SDN and business models.

Moreover, the design of the business model is based on the STOF business model framework. This framework has been used multiple times in academia and in industry to design business models for cutting edge services, but it is not yet applied on the domain of computer network technologies. The use of STOF framework for designing the SDN business model can enhance the external validity of STOF framework by accumulating knowledge for the domain of computer networks.

1.3 Issue stakeholder

Central issue stakeholders are IT service providers and more specifically Capgemini Infrastructure Outsourcing Netherlands.

The definition that is used for the term "IT service provider" in this master thesis is based on the official definition of ITIL® version 2011 for the Type III service provider (AXELOS, 2011). The definition is quoted in the next lines:

> *Service provider: "An organization supplying services to one or more internal customers or external customers. Service provider is often used as an abbreviation for IT service provider."* (AXELOS, 2011)
>
> *Type III service provider: "A service provider that provides IT services to external customers."* (AXELOS, 2011)

The SDN technology is dynamically emerging and for the time being only some early adopters are making full use of the fruitful outcomes from the technology's utilization. But, still an IT service provider has to create the know-how and be ready to provide a service when it will be needed (Venkitachalam & Busch, 2012) as well as seize the fruitful outcomes of the technology by integrating it in its infrastructure. Alertness and knowledge creation will give more chances for competitive

advantage to the firms that will have already developed knowledge on the technology before it becomes mainstream.

1.4 Research Objectives

Main research objectives of this master thesis are the "identification of the current state and future trends of the SDN technology both in the market and the academia". And secondly *"the design of a business model for delivery of SDN enabled services"*. The business model will be designed based on the assumption that it is intended for internal adoption and use of the SDN technology in the datacenters of an IT service provider. Much more, an IT service provider in order to achieve efficient utilization of tangible and intangible resources, and maximization of the value that is generated and captured when providing a service enabled by the SDN technology to its customers, has to have a viable business model (Bouwman, De Vos, & Haaker, 2010). The business model design will focus on the commercial phase of it. As stated by (De Reuver, Bouwman, & MacInnes, 2009), the phases that a business model is passing through to its maturity are three. First is the development/ R&D phase, next comes the implementation/ roll-out phase and finally is the commercial phase. Our business model will focus on the commercial phase, so as to enable an IT provider to deliver SDN services in the short term, as well as to give the understanding of how does a viable business model that integrates SDN technology in an IT service provider's datacenter infrastructure should look like.

The business model framework that will be used in this master thesis will be presented in chapter three, where in-depth literature review and comparison of different business model frameworks takes place. So, an additional research objective of this master thesis is *"the identification of the business model framework that supports the case of the SDN technology adoption from an IT service provider"*.

Based on the research objectives of the master thesis, analogous research questions are phrased as well. The research questions serve the need of the research objectives' implementation and they are analyzed in the following sub-chapter.

1.5 Research Questions

Main Research Question

Which would it be a business model for integration of SDN services in an IT service provider's service portfolio?

Research Question 1: *What is the state of the art of SDN?*

> **Sub-Research Question 1.1:** *How does the current market and technical state of SDN looks like?*
>
> **Sub-Research Question 1.2:** *Which are the future trends of SDN?*

The first research question is answered in the second chapter of this master thesis. A detailed literature and desk research of the current state of the technology as well as the future of it is necessary in order to design a service based on the SDN technology. This state of the art analysis

supports the academic contribution of the master thesis too, since a comprehensive survey for the SDN technology is made. The first sub-question focuses on the current evolution of the technology and the second one is oriented in the prediction of the future of SDN. Both of the questions are answered based on the latest publications and reports by academia and ICT industry.

With this question the first part of the master thesis is established. The first part of the thesis includes the literature review and the research's design. The second part includes the implementation of the service's design based on the research and planning that is made on the first part of the thesis.

Research Question 2: *Which business model framework best supports the design of an SDN business model?*

This question is to be answered in the third chapter of this master thesis. It is important that the right business model framework is going to be chosen for the design of the SDN based service. Academia offers many different business model frameworks, but only one of them will be considered to support the design of the required SDN service.

Research Question 3: *Based on the selected business model framework, how does a viable business model that integrates SDN technology in an IT service provider's datacenter infrastructure, looks like?*

This is the research question that is introducing the master thesis' second part; i.e. the design of the business model happens. The third research question is based on the research methodology that is used in the fourth chapter of the master thesis, as well as the literature review of the second and third chapter. Moreover, in the process of answering the third research question, the selected business model framework is going to be parameterized in order to be aligned in the best possible way with SDN technology and the domain of computer networks. This parameterization will be one more of the academic contributions of this master thesis.

1.6 Research Approach

1.6.1 Scope

Scope of this research is the design of an SDN service based on the chosen business model framework. Main stakeholder and user of the business model will be the IT service provider.

1.6.2 Research Methodology

The business model will be designed by making use of qualitative research techniques such as in depth literature research and interviews with experts from industry and academia. In the next section the research methodology of this thesis is discussed. This master thesis' research methodology is based on *qualitative exploratory methods*. The needed bibliography and the academic theories required are going to be made available through in depth *literature research* in the scientific domains that the master thesis is related with. Required information relevant with the technology of SDN, the vendors that are producing compatible software and hardware, the followed strategies and the business models, would be filled in *by literature research* as well. Additional information for the creation of the business model will be gathered by *semi-structured and unstructured interviews* (Verschuren, Doorewaard, & Mellion, 2010). These interviews have been scheduled in order to acquire more information for the answering of the research questions as well

as to validate the initial conclusions from the literature. The research for the design of the business model will be based on a *single case study* with unit of analysis "the required IT service provider business model", referred as "case" too (Yin, 2009) (Verschuren, Doorewaard, & Mellion, 2010).

For the evaluation of the designed business model, the method of data *triangulation* will be used in order to validate the draft - "quick scan" version of the business model. Different managers from the IT service provider company, the industry as well as researchers from the academia have been interviewed and the business model has been discussed, evaluated and updated (Ammenwerth, Iller, & Mansmann, 2003), (Denzin, 1970).

As stated in (Verschuren, Doorewaard, & Mellion, 2010) the external validity of research projects based on case studies might be "under pressure" because of the in depth research of a specific domain and the loss of focus for its generalization. So the external validity of the designed business model can be assured by interviewing many different vendors and potential customers from different work groups and sub groups. For example the experts from the telecommunications hardware industry that have been interviewed are be from different companies. Additionally, employees from multiple departments of the IT service provider have been interviewed to get a better insight in the state of the company and increase the validity of our findings.

1.7 Structure of the master thesis

This maser thesis spreads over six chapters. These chapters are going to be interconnected as a logical continuation of each other. Much more in the following figure there is visualized the interconnection of the thesis' chapters as well. In more detail, the content of each chapter is as explained in the following paragraphs:

Chapter 1 – Introduction:

This is the current chapter that is making a general reference to the contents of the master thesis, the issue stakeholder, the research objectives, questions, etc.

Chapter 2 – State of the art of SDN - Current status and future trends:

The second chapter is giving answer to the first research question and its sub research questions as well. It is related with the state of the art of SDN and its future trends. The outcomes of chapter two will be taken in consideration for the design of the business model in chapter five.

Chapter 3 – Business Model Literature Review:

In the third chapter of the master thesis is given answer to the second research question. In this chapter a review of different business model frameworks is made. In the conclusion, the best fitting framework to the case of SDN is chosen to be used for the design of the business model.

Chapter 4 – Research design methodology:

In the fourth chapter, after the choice of the business model framework and the in depth analysis of state of the art of SDN of the previous chapters, the research design of the thesis is made explicit. Through the chapter is analyzed the research design methodology, the data collection methodology and the way that the chosen business model framework is used.

Chapter 5 – Business model design:

The fifth chapter is the initiation of the second part of the thesis where the business model is designed and the third and last research question is answered.

Chapter 6 – Discussion and Conclusions:

Conclusions, limitations as well as future research, in addition with some recommendations and reflection of the whole thesis, are included in this chapter.

1.8 Confidentiality

This master thesis research is conducted internally with the Dutch brunch of Capgemini and more especially with its infrastructure outsourcing (IO) department. Some details such as names of managers, specific departments, costs of services, etc., are not referred in the public version of the master thesis in order to protect the company's existing business models and strategic plans. Moreover, in general all of the contacted internal and external interviews are anonymized. This is been done in order to protect the privacy of the interviewees as well as to allow them to freely express their thoughts; and to keep intact the impartiality of our research.

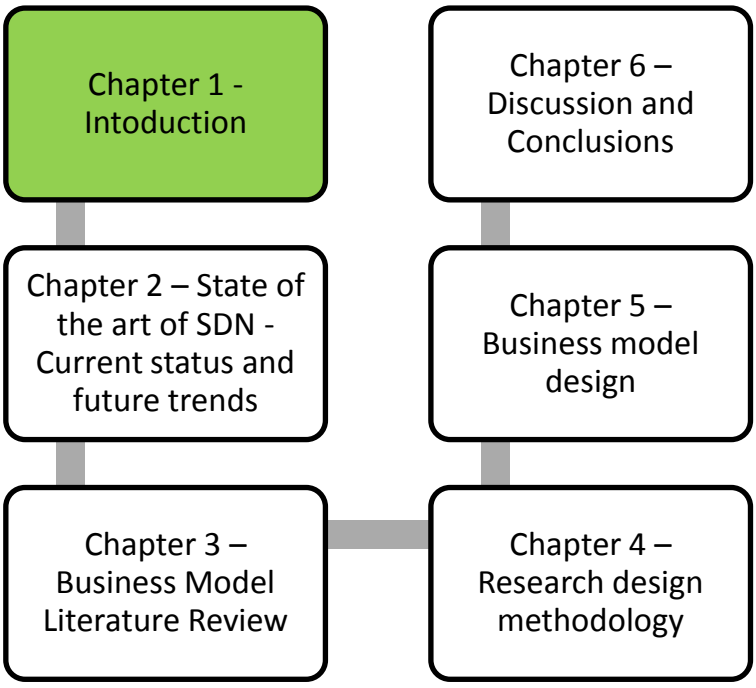

Figure 1 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

2 Chapter 2. State of the art of SDN - Current status and future trends

2.1 Introduction

This chapter is dedicated to the exploration of current developments and applications of SDN architecture as well as the future trends of the technology in the domain of computer networks. The research methodology that is followed in this chapter is literature research based on academic articles, accredited blogs and official websites of software and hardware companies of the domain. Moreover, main objective of the chapter is to give an answer to the following research and sub-research questions on which the rest of the master thesis will be based on:

Research Question 1: *What is the state of the art of SDN?*

Sub-Research Question 1.1: *How does the current market and technical state of SDN looks like?*

Sub-Research Question 1.2: *Which are the future trends of SDN?*

In the next paragraphs are mentioned entrepreneurial activities of established vendors as well as activities of startups that are active in the SDN domain. Furthermore, a specific section is dedicated to use cases of SDN and large scale implementation examples from the private sector are explored. These use cases are carefully selected and are going to be integrated in the design of the business model's services. Additionally, many academic papers are cited through the chapter. Most of the papers are referring to the current status of a specific segment of SDN, which are exploiting as well. Of course, in their conclusions most of the scholars are referring to future directions and open research topics, something that gives a better understanding about the future trends of SDN. Additionally, some broadly known events, conferences and workshops dedicated to SDN are mentioned in order to underpin the increased interest of academia and industry for the technology.

To enable a smooth transition to the following subchapters, a brief reference to the technical terminology used through the chapter has been done and more details can be found in the appendix. So a subchapter that explains some of the most significant technical concepts that are mentioned in the thesis can be found in the appendix. Therefore, readers that want to have a better understanding of concepts related to *OSI model, switches and routers, SDN controller, northbound and southbound interfaces, logical and physical network topologies* can refer to the appendix of the thesis before continuing reading the current chapter.

2.2 Definition of Software-Defined Networking Architecture

SDN is "an emerging network architecture where network control is decoupled from forwarding and is directly programmable. This migration of control, formerly tightly bound in individual network devices, into accessible computing devices enables the underlying infrastructure to be abstracted for applications and network services, which can treat the network as a logical or virtual entity." (Open Networking Foundation, 2013)

The upper is a definition of SDN as quoted from the white paper of the Open Networking Foundation (Open Networking Foundation, 2013). The Open Networking Foundation (ONF) is a nonprofit organization that is driven by the users' demands in the market. ONF was founded in 2011 by the collaboration of the following companies: Deutsche Telekom, Facebook, Google, Microsoft, Verizon, and Yahoo!. At the moment the Foundation counts 138 members, including among others large telecommunication service providers, networking equipment manufacturers, enterprise users and semiconductor companies, as well as startups that are developing innovative software and hardware related with the SDN architecture. (Open Networking Foundation, 2014)

Another definition as quoted from the SDN related book of (Nadeau & Gray, 2013) is the following:

"Software-defined networks (SDN): an architectural approach that optimizes and simplifies network operations by more closely binding the interaction (i.e., provisioning, messaging, and alarming) among applications and network services and devices, whether they be real or virtualized. It often is achieved by employing a point of logically centralized network control—which is often realized as an SDN controller—which then orchestrates, mediates, and facilitates communication between applications wishing to interact with network elements and network elements wishing to convey information to those applications. The controller then exposes and abstracts network functions and operations via modern, application-friendly and bidirectional programmatic interfaces." (Nadeau & Gray, 2013)

We believe that the second definition is broader and covers wider the domain of SDN, so we are choosing this definition as a reference to the term of SDN from now on.

Additionally, in the next figure the SDN architecture is depicted in a simplistic sketch in order to give a better understanding of the centralized controller and the way that it orchestrates the entire network. So in the figure can be seen that each independent router and switch is solely aware of its near neighbors' state but is not aware of its distant peers' state. On the contrary, the centralized controller has knowledge of the whole network's structure and state, so is able to orchestrate the network by creating traffic flows for the connection and communication of these distant entities inside the network. Very important to mention is that for an operable SDN network the minimum requirements are an SDN controller and SDN compatible switches. In the next paragraphs all these concepts of SDN architecture will be analyzed in detail as well.

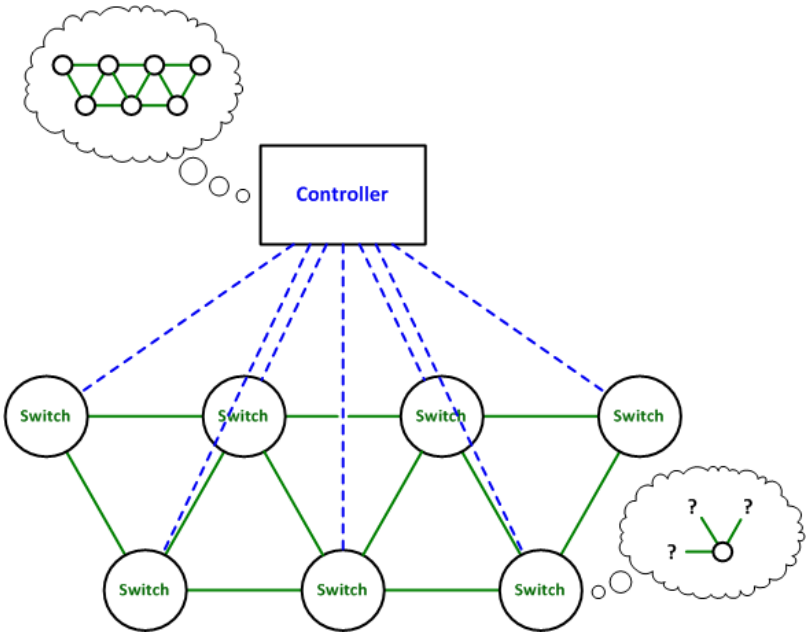

Figure 2 – Simplistic representation of SDN architecture (Stretch, 2013)

Contrarily to the upper simplistic figure, the next figure depicts in detail the functional architecture of SDN. In the figure can be seen the role of the controller as the orchestrator of the network. The northbound and southbound interfaces (see appendix) that are responsible for the communication of the controller with the upper and lower levels of the network are seen as well.

All of the concepts seen in the functional architecture figure are analyzed in the next sub-chapters. So, this figure can be used as a reference for the rest of the analysis.

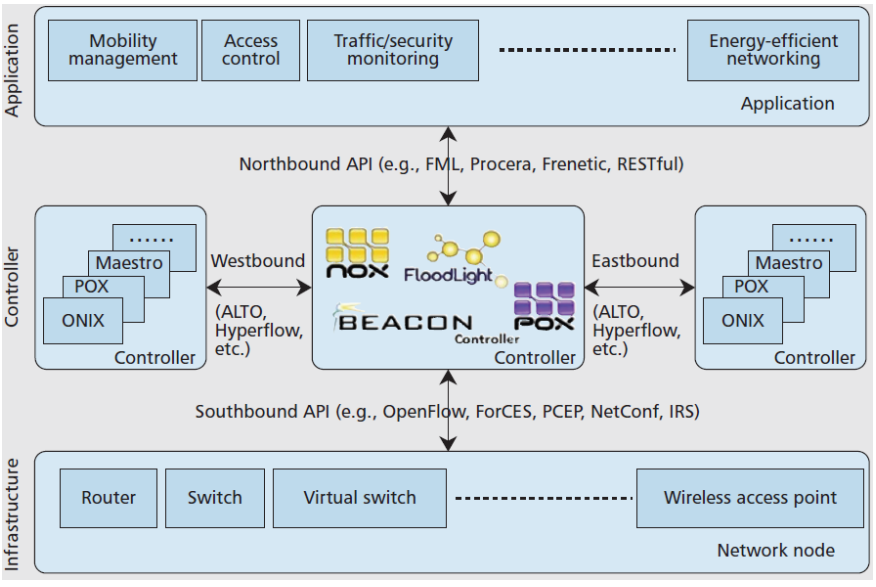

Figure 3 - SDN functional architecture (Sezer, et al., 2013)

2.3 Current market and technical state of SDN

This is the first part of chapter 2, in which the analysis of the current state of SDN technology in the market, industry and academia takes place. This analysis scopes to give an answer to the first sub-

research question. While the second part of the chapter analyzes the future trends of SDN and gives an answer to the second sub-research question of research question one.

2.3.1 SDN protocols – Southbound interfaces

This subchapter describes the SDN protocols or else southbound interfaces that are enabling the SDN architecture. OpenFlow, SoftRouter and ForCES are presented so as to give a spherical view of some south bound interface options that are available at the moment that this master thesis is authored.

OpenFlow

The most broadly used open source protocol that is utilized for the enabling of SDN architecture is the OpenFlow protocol and is developed by ONF (Big Switch Networks, 2014). *"OpenFlow is the first standard communications interface defined between the control and forwarding layers of an SDN architecture. OpenFlow allows direct access to and manipulation of the forwarding plane of network devices such as switches and routers, both physical and virtual."* (Open Networking Foundation, 2013).

In the following figure can be seen the architecture of SDN and the role that the OpenFlow enabling protocol has in it. More precisely, the SDN controller is able to have an overall view of the whole network. The administration of the network is made by a single logical point which has a significant impact in the simplification of the procedure. While the SDN architecture achieves easier and faster administration of the network, in the same time it helps the network devices to have less workload as well. Since the network devices do not have to execute complex routing algorithms anymore, but they solely have to execute the SDN controllers' commands (Open Networking Foundation, 2013).

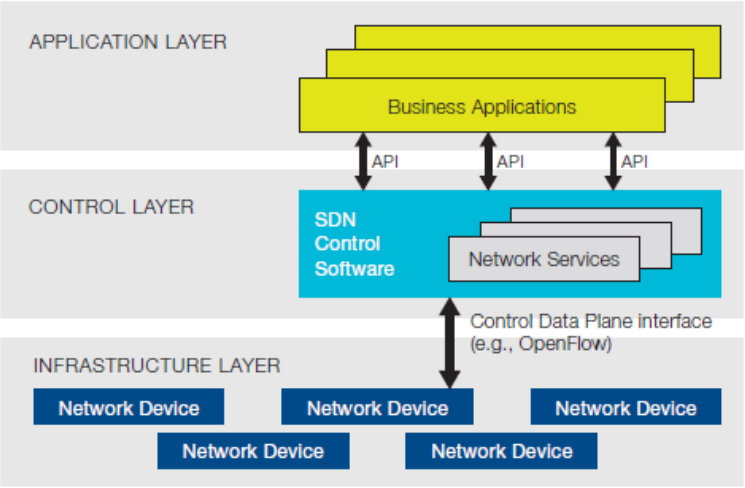

Figure 4 - SDN Architecture with OpenFlow running in the control plane

The first time that OpenFlow protocol was made available for public use was on March 2008 with the version 0.2. After many other intermediate releases, on December 2009 version 1.0 of the protocol was made public as well. The latest published version is 1.4, which was made publicly available on October 2013. In this version the updates and supported functions as well as the compatible infrastructure with the networking market are much evolved, especially when compared to the previous versions (Open Networking Foundation, 2013).

This fact proves that large investments are made on the development of SDN technology, in an attempt to make SDN mature in the industry and eventually take over other conventional

technologies. Much more it is proving that ONF is really listening to the needs of SDN market and its users. By the time many other famous protocols and functions such as IPv6 and multiple controller support are integrated from the ONF to OpenFlow's interface. In the following figure there are visible all the improvements made from version 1.0 to the latest version 1.4 of OpenFlow protocol. The figure is cited from the paper of (Ren & Xu, 2014).

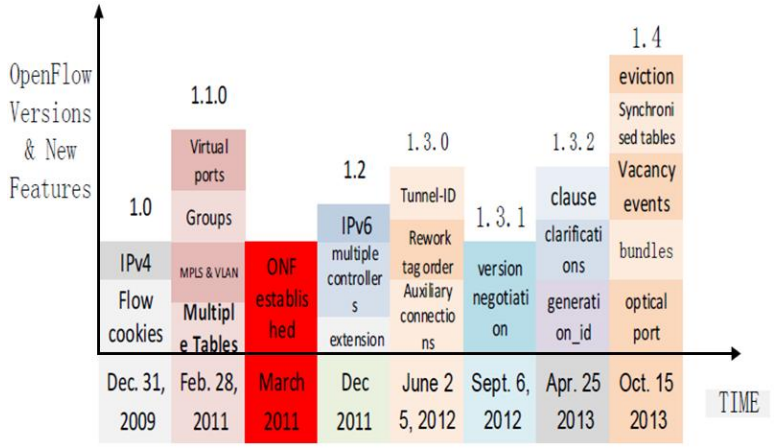

Figure 5 - Evolution of the OpenFlow protocol through the past years (Ren & Xu, 2014)

SoftRouter

SoftRouter was one of the first SDN related proposed architectures. It is designed by (Lakshman, Nandagopal, Ramjee, Sabnani, & Woo, 2004) and its main idea is to separate the control plane from the data plane while enabling many distinct software controllers in the network. The authors supported that the SoftRouter architecture is having five main benefits. 1. Increased Reliability 2. Increased Scalability 3. Increased Control Plane Security 4. Ease of adding new functionality and 5. Lower Costs (Lakshman, Nandagopal, Ramjee, Sabnani, & Woo, 2004). In general, these are the benefits that the rest of the recent developing architectures are claiming to be providing to their users as well. Another architecture that is mentioned in the paper of the SoftRouter authors is ForCES and is the next to be presented.

ForCES

ForCES stands for "Forwarding and Control Element Separation". It is designed by the Internet Engineering Task Force and it could be an alternative solution of OpenFlow in SDN implementations. On the one hand both architectures are having as a goal the standardization of the way that the separated control and data planes are going to communicate. On the other hand, major differences of ForCES and OpenFlow are the following ones. Firstly, with the ForCES the architecture of the network stays the same while OpenFlow transforms it and converts the data plane elements to devices that are simply administered by the control element of the architecture. Secondly, the ForCES allows multiple controllers and multiple data elements in the network, while OpenFlow is focusing on unique centralized control plane that is administering the whole network. (IETF, 2014)

The Internet Engineering Task Force and the Internet Research Task Force (IRTF) have formed multiple research groups, one of which is the Software-Defined Networking Research Group (SDNRG). The SDNRG is having annual meetings and is discussing future trends of the SND as well as challenges to be met. The group is chaired by David Meyer and Dr. Nick Feamster (SDNRG, 2014).

2.3.2 SDN Controllers

An SDN controller is the responsible network element for the smart centralized networking concept of software defined networking. It is accountable for the flow control of the network's traffic. Till now there are many different implementations of controllers; some of them proprietary and some others under free licenses. Through the following lines are presented some broadly used SDN controllers. Emphasis is given to include controllers designed both by the academia and the industry. The SDN controllers are making use of the earlier analyzed SDN protocols (OpenFlow, SoftRouter, ForCES), which allow the intelligent management of the whole network.

NOX

NOX is the first SDN controller to utilize the OpenFlow protocol. It was designed by Nicira Networks - in 2012 Nicira got acquired by VMware (Williams, 2012) - and was given for free to the research community under an open source license in 2008. Many other controllers are based on its source code and Stanford University is making use of NOX controller as well. An alternative of NOX is *POX* which is programmed with the Python programming language, whereas NOX is programmed with C++. In the official website of NOX it is referred that the controller is mostly targeting recent Linux distributions such as Ubuntu, Debian and RHEL. (NOXRepo.org, 2014)

Beacon

"Beacon is a fast, cross-platform, modular, Java-based OpenFlow controller that supports both event-based and threaded operation." (Erickson, 2013) is the official definition of Beacon controller as cited from its official website. The controller is developed by Stanford University and its uniqueness is that the Java implementation allows the controller to be executed in multiple platforms. The project is open source under the GPL v2 license and its main focus is to target more the academic community than the industry. (Erickson, 2013)

Floodlight

Floodlight is the evolution of the Beacon controller for industrial use. It is programmed by the startup company named "Big Switch Networks" and it is still based on the Java programming language. The floodlight controller is still open source under the Apache license. In the official website of the project it is referred that the project counts more than 200.000 lines of code and 15.000 downloads. (Project Floodlight, 2014)

OpenDaylight

The OpenDaylight Project started in 2013 and is an Open Source Programmable Networking Platform managed by the Linux Foundation. The project focuses on the development and expansion of SDN architecture in the market. Involved in the OpenDaylight Project are many companies from the telecommunications industry, most of them member of ONF as well (Opendaylight, 2014). To name a few of them: Brocade, Cisco, Citrix, Ericsson, HP, IBM, Juniper Networks, Microsoft and Red Hat.

2.3.3 Use cases of SDN

Some of the most common use cases of SDN technology are the following:

- Applications in wide area networks, where policies can be easily applied in real time and convergence of services can take place in a much more flexible way in order to serve the need of the users.
- Deployment of SDN can be made in data centers as well. SDN can enable virtualization of the network's functions and enable high level scalability, improved resource utilization and carbon footprint minimization.
- Moreover, SDN can find application in public and private clouds by providing high flexibility in the provision of cloud services.
- Of course much more use cases can rise based on the creativity of the developers and the endless possibilities of the SDN architecture. Exploitation of the central-based administration that SDN architecture provides can lead to radical innovations.

All of the above can lead to maximization of the delivered to the customer value, the assurance that the network's infrastructure is optimally utilized and potentially the reduction of CapEx and OpEx of a company (Open Networking Foundation, 2013). In the next subchapters there are going to be mentioned and analyzed most of the broadly known SDN use cases.

Purpose of Use cases' Review

All of the following use cases are presented to create understanding of how the SDN technology can be used as well as how its users can be benefited from it. So through the use cases it is pinpointed the added value that SDN can provide and the usability of it depending on the context. Additionally, some of these use cases are going to be integrated in the design of the business model. Each one of them will be explored of how can it be an advantage for an IT service provider. The use cases that will be regarded as useful will be transformed into service concepts for the service provider. This research takes place in chapter five. For the time only the use cases are analyzed through the next lines.

Furthermore, in the appendix of the thesis some case descriptions of early adopters of SDN can be found. These cases can give a better understanding for the way that large organizations and companies are benefited from implementing SDN technology in their infrastructure. Organizations and companies that are having their cases mentioned are Stanford University, Google and Kanazawa University Hospital. Important to mention is that common points of interest for all three cases are the automation that SDN offers to the users, the enhanced security and the maximization of the network source's utilization. Specifically for Google the utilization rate reached 95% for its backbone that supports traffic between its datacenters, known as "G-scale" too.

Network Policies Management

SDN enabled networks are having the privilege of being flexible and dynamic. The network administrators are given the opportunity to create policies that can be applied dynamically by the centralized controller to the whole network's domain. Ethane architecture, an early version of SDN, (Casado, et al., 2007) is a popular example for policy making in SDN. Ethane allows the creation of policies that will be automatically managed by the controller. This allows the administrators to update the policies of the network in real time in order to have instant results. Casado et al designed

together with Ethane an experimental network programming language called Pol-Eth that allows the administrator to apply network policies guided by the central controller.

Unique characteristic of Ethane architecture is that all of the traffic between end-hosts is orchestrated based on the commands of the centralized controller. None of the entities of the network are allowed to communicate with each other if there is no prior policy allowing to do so. So when a packet that represents a flow is received by the controller, there is made background check of whether or not there is a policy that allows the specific flow. And afterwards, if the flow is accepted the controller that has knowledge of global network topology, performs route computation for the permitted flow.

The biggest difference of SDN architecture compared to the current state of the art of conventional distributed networks is that they do not support knowledge of the global network topology based on a single topology. Moreover the calculation and dedication of routes in the network based on a single entity, the controller, is a novel characteristic as well.

Network Availability

Load balancing

SDN allows the bandwidth's control that is allocated in a network based on the centralized controller. The controller can dynamically allocate more resources when it is needed or in different cases can free the unnecessary resources in order to maximize the utilization efficiency of the network.

Currently network hardware vendors like F5 Networks and A10 Networks are having offers for load balancing founded on their own proprietary architecture equipment. This is one of the reasons that the two companies the last years are suing each other for patent violations (Matsumoto, LightReading, 2010). F5 was the first company to offer load balancing solutions and later on A10 launched the EX series for load balancing support as well (F5 Networks, n.d.), (A10 Networks, 2014).

Furthermore, popular standards that offer bandwidth control in conventional networks is the Transparent Interconnection of Lots of Links (TRILL) of IETF and Shortest Path Bridging (SPB) or else IEEE802.1aq of IEEE. TRILL and SPB are rumored that could be substituted by SDN as OpenFlow protocol matures and gets broadly accepted by the market (Banks, 2013).

As for SDN, at present there are two famous implementations for load balancing, the Plug-n-Serve and the Aster*x. Both are utilizing the OpenFlow protocol and they are designed respectively by (Handigol N. , Seetharaman, Flajslik, McKeown, & Johari, 2009) and (Handigol N. , et al., 2011). Both of the solutions can track the activity and the load of the network in real time and manipulate the extra flows to servers that are underutilized by the ones that are having too high traffic. The manipulation of the traffic depends on the configuration that the administrator has made in his network. Important as well is that when new servers are added in the cluster the referred solutions are recognizing the new infrastructure and are assigning to it tasks for execution. It has to be mentioned that Aster*x load balancer is used by Global Environment for Network Innovations (GENI). GENI is a U.S.A. virtual laboratory - testbed that is spread national wide and scopes to promote innovation in the field of computer networks (GENI, 2014).

Fault tolerance

One more feature that can be enhanced with SDN is the dynamic and real-time link recovery in case of a network element's failure. More precisely, in the non-programmable networks each switch is having knowledge only about its neighbors' state, so the new link might after the recovery not be the most optimum one. The abovementioned IEEE802.1aq standard can provide this feature, as well as the Spanning Tree Protocol or else IEEE 802.1D of IEEE and Hot Standby Router Protocol (HSRP) a Cisco proprietary protocol. On the other hand, in SDN enabled networks the controller is having knowledge of the whole network's state. So in case of a switch failure, the controller will change the flow of the data dynamically and more efficiently than it will happen in a conventional network. But researchers support that in carrier grade networks the response time for a recovery should be less than 50ms, while for SDN this is a difficult task to be accomplished due to the dependency to the unique in the network centralized controller (Staessens, Sharma, Colle, Pickavet, & Demeester, 2011).

Security

Distributed Denial of Service attack recognition

The SDN technology is giving the opportunity for software based traffic analysis. Due to this fact more complex algorithms of analysis could be run and better outcomes could be seized. This is really important for the detection of malicious acts and requests to the administered network. For example, (Braga, Mota, & Passito, 2010) propose a way that Distributed Denial of Service attacks (DDoS) could be recognized more efficient in SDN environments running the OpenFlow protocol and the NOX controller. The implementation of Braga et al is just mentioned as an indication of the capabilities of SDN in the field. Many other are the DDoS recognition techniques that are proposed by other researchers.

Validation of source address

One more use case of the SDN in the security domain is the validation of the source address. Based on the proposal of (Yao, Bi, & Xiao, 2011) in case that a packet is not having a registered rule in the flow table, the switch can forward the specific packet to the controller. Then the controller can validate of whether the source is valid or not in order to make the decision to keep proceeding the packets or just drop them in case it is a malicious activity. This specific proposal of Yao is implemented once more with the combination of the popular solutions of OpenFlow and NOX and its given name is VAVE.

Wireless applications

(Yap, et al., 2010) invented an open-source platform for mobile networks called OpenRoads. They support that they have designed an extension for OpenFlow. As stated in their paper *"you can think of OpenRoads as OpenFlow Wireless".*

Of course there are many more use case of the SDN but this thesis will not focus on completely covering this topic since its main focus is the design of a business model and not to create a survey. On the next subchapter there will be mentioned some of the implementations that have taken place till now in the industry and the academia by early adopters of the SDN technology.

2.3.4 Established SDN infrastructure vendors

In the following table could be seen some of the most popular vendors' switches that are supporting the OpenFlow architecture. It is clear that companies with worldwide recognition are interested in the SDN technology and are researching and developing their own offerings based on it.

Anyhow further than the developments of the established vendors of the computer networking industry, interesting and crucial for the future formation of the SDN are the implementations of the startups of the domain too. So in the next section there is a brief analysis of the startups of the SDN domain as well.

Maker	Switch Model
Arista	7124FX
Ciena	Coredirector firmware v6.1.1
Cisco	Catalyst 6xxx, Catalyst 3750, Nexus 9000, Nexus 7000
Juniper	Junos MX-Series
HP	5400zl, 8200zl, 6200yl, 3500/3500yl, 6600
NEC	PF5240, PF5820
Pronto	3290, 3780
Toroki	Lightswitch 4810
Dell	Z9000, S4810
Quanta	LB4G
Brocade	NetIron CES 2000 Series
IBM	RackSwitch G8264
Pica8	P-3290, P-3295, P-3780, P-3920

Table 1 - Switches that are supporting the OpenFlow architecture (Lara, Kolasani, & Ramamurthy, 2013) & (Mendonca, Astuto, Nguyen, Obraczka, & Turletti, 2013)

It has to be mentioned that there are two types of switches in OpenFlow networks. The hybrid switches and the pure switches. Hybrid switches are supporting both the OpenFlow protocol as well as the traditional already used protocols. On the contrary pure switches are only supporting the OpenFlow implementation. Most of the switches at the moment in the market are hybrid. Last but not least, there are pure software implementations of OpenFlow switches as well. Four of the most popular ones are Open vSwitch, Pantou, Indigo and ofsoftswitch13.

2.3.5 Answer for Sub-Research Question 1.1

After the research and analysis of multiple domains of academia and industry for the latest developments of SDN, the answering of the first sub-research question is feasible.

> **Sub-Research Question 1.1:** *How does the current market and technical state of SDN looks like?*

SDN is currently still in its early adoption phase and OpenFlow is the dominant enabling protocol. However, despite the fact that OpenFlow is mainly accepted, its latest 1.4 version is not supported by many vendors. Moreover, there are many different SDN controllers in the market and much more are the nonproprietary projects that big established infrastructure vendors support. Additionally, standardization organizations and big established infrastructure vendors are promoting the technology with every mean and strategy; because all of them want to secure a share of SDN market in this early phase. Last but not least, it has to be mentioned that use cases of SDN are focusing on: network management and availability, security assurance and innovative wireless implementations.

But most of the known early adopters of SDN technology that are having wide area network implementations of SDN are large enterprises, research institutions and universities. The diffusion of SDN technology for the entire market is yet to come.

2.4 The future of SDN

Following in this part of chapter two, will be the analysis of the future of the SDN through the view of the industry and the academia, as well as through the aspect of market analysts. This following part will give an answer to the second sub-research question and will conclude on the state of the art of the SDN.

2.4.1 Startups based on SDN

Specific reference has to be made for the startups that are basing their products and services on the SDN technology. As academic theories support that economic growth can derive from small innovative firms – startups (Andersen, 2013); and sustainable growth in the domain of the computer networking is the one of the focus points of this master thesis. Startups are usually serving niche markets and they are growing in these specific segments. It can be considered that this growth in specific segments is formulating the future of the SDN technology as well.

Moreover, many are the paradigms that a bigger company is acquiring a startup in order to incorporate new innovative solutions in its own portfolio. One of the latest and biggest acquisitions is the one of Nicira. VMware acquired Nicira for the price of $1.26 Billion (Williams, 2012). Additionally, as stated above as well, ideas implemented from startups can be many times the next big thing to have impact in the industry. And this is one more reason to refer to SDN startups through the following lines. One more fact that highlights the importance of the startups' participation in the SDN, is that recently the ONF announced the reduction of membership fees for startups incorporated into the last two years. The fees will be annually equal to 1.000 US dollars instead of 30.000 US dollars that the rest of the potential members has to pay. ONF has noted that all of the companies independently of their membership fee payment rates they will have the same rights and recognition in the foundation (Nickle, 2014).

Some of the most innovative startups that are getting a lot of publicity lately are Big Switch Networks, Pica8, Embrane and Midocura. The trends that these startups are exploiting are the design of bare metal switches fully compatible with OpenFlow, the utilization of the latest versions of OpenFlow and the virtualization of the whole scale of OSI from top to bottom i.e. from OSI level 7 to OSI level 2.

More information about SDN startups can be found in the appendix.

2.4.2 Gartner's Analysis

Gartner is an information technology research and advisory firm founded in 1979 and based in Connecticut, U.S.A. It is regarded as one of the most trustworthy and accurate companies in the domain.

On February 2014 it published a list of the top 10 technology trends for the year 2014 that will have impact at least for the next three years as well. The technologies, among others, are revolving around cloud computing, mobile technologies and software-defined entities. Additionally, the company refers that has chosen these specific technologies due to their impact in many different

domains of the industry and their disruptive nature as well. Moreover Gartner states that these technologies can have positive or negative impact to any company depending on its core business and the core business of its competitors as well. So smart strategic moves should be made from the CIOs and all the other C-level executives of companies active or closely related with the trending technologies.

Gartner is referring to the SDx or else the Software-Defined Everything. And defines that x can be *"infrastructure (that is, SDI), networking (that is, SDN), storage (that is, SDS) and data centers (that is, SDDCs)".* The article closes by referring to the general concept of the Software-Defined Everything that wants to free the users from proprietary software and hardware as well as evolve the current state of the networks to a more flexible and easier manageable one. (Gartner Inc., 2014)

2.4.3 Gigaom's Research

Gigaom Research was founded in 2006 by the Indian-American Om Perkash Malik, has offices in San Francisco and New York and, as stated in the official blog of the company, *"is the leading global voice on emerging technologies"*. In the blog of the company is stated as well that monthly more than six million unique users visit it. Recently Gigaom made a research underwritten by the OpenDaylight project. The research is entitled "SDN, NFV, and open source: the operator's view" (Leary, 2014) and some of its most important findings will be analyzed in the following lines. Important to be mentioned is that the research had a sample of 600 operators located in North America.

Leary in the specific report of Gigaom supports that SDN and NFV are technologies that are going to alter the networking industry forever. Furthermore he supports that the technologies will determine the success or even the failure of the operators over the next decade. As for the use cases and the domains that the technologies will be used, the results fluctuate and no clustering can be applied to them. Many operators are planning to use the SDN and NFV for their datacenters, others for wide area networks and others for implementing more efficient bring your own device (BYOD) solutions. But most of the operators are planning to firstly integrate the technologies to their datacenters.

As for the factors that are hampering the diffusion of the two complementary technologies, on the top of the list are the security issues, the migration costs, the lack of clear and consistent capabilities as well as the unproven performance and reliability. Interestingly, the interoperability of the technologies with the current infrastructure of the providers is at the bottom of the same list. Regarding the preference of the operators for open systems they are really positive with them and are showing a clear preference for them. Once more, interestingly the operators prefer open systems and open source solutions, but they want them served from commercial suppliers. Leary comments on the last one that most probably the operators want to seize the positives of the open source systems but in the same time they want the confidence and the guaranties of the commercial partners. Closing, the operators are seeing as challenges for the SND and the NFV the improvement of the security and reliability of them.

Despite of the impediments of the current state of the two technologies, the majority of sampled operators support that will integrate the technologies in their infrastructures till the end of 2015. Something that Leary supports that is most possible to happen in more than ten or even twenty years based on previous experience with networking technologies that came to finally be mainstream acceptable.

Moreover, interesting to be mentioned is that on another research of Gigaom, the analyst (Doyle, 2013) refers that by 2018 the SDN will be the "*next big wave of investments*"; which is expected to be equal with $2.45 billion.

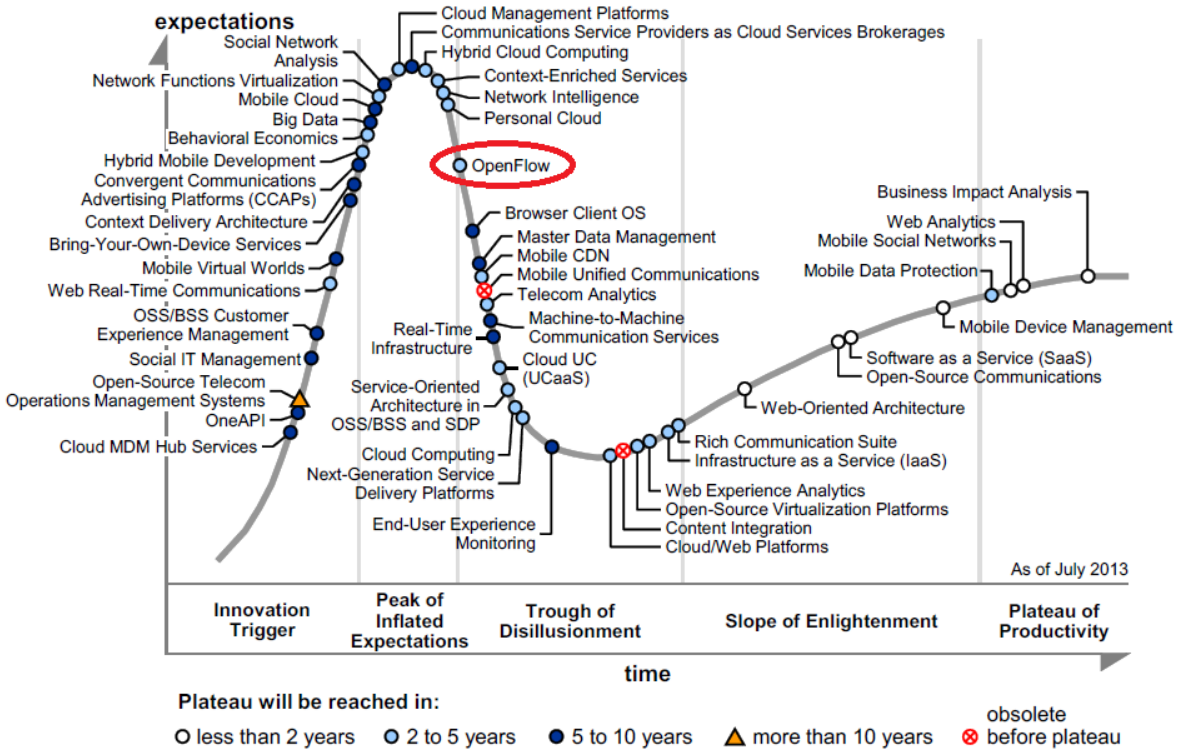

Figure 6 – Current phase of OpenFlow based on Gartner's Hype Cycle (Gartner, 2013)

2.4.4 Academic research focus

(Lara, Kolasani, & Ramamurthy, 2013) address some open research questions. The authors are supporting that studies should be contacted for the possibility of large scale wide area networks (WAN) implementations of SDN networks. They mention that it is of a high importance that performance and scalability experiments are made in order to validate the above mentioned issue. Next, the authors support that emphasis should be given in evolving the OpenFlow protocol to the rest of the networking devices even more. They mention that OpenFlow started being developed mainly with switches in mind. But now it is the time to exploit the protocol for the rest of the network devices as well. Moving on to the next open research question of the same authors, they mention that with the development of OpenFlow's 1.2 version the road for multiple cooperating controllers in a network has opened now. Multiple controllers in the same network will enhance the vulnerable points of SDN in issues of availability and reliability. Following, Lara et al are mentioning that there is need for experiments made based on tangible-real network infrastructure and not on virtual based switches such as the Open vSwitch. Additionally, there is mentioned that there is need for debugging network applications. Since the networks are starting to transform to software defined, there is going to be need for debugging applications as well. Closing with their proposals, Lara et al are mentioning that real life and large scale implementations, such the one of Google, are needed to move the technology forward.

In another paper, authored by (Mendonca, Astuto, Nguyen, Obraczka, & Turletti, 2013) there are some more future directions and open research questions given for the SDN. Mendonca et al are

referring among others in issues of information centric networking (ICN) and heterogeneous network support. Regarding the first topic, it is a newly proposed idea that can replace the internet as we know it nowadays. ICN is an architecture that focuses separately on the content of the information and its transition. This separation concept is matching the key concept idea of the SDN and some research has already been done on the domain of how SDN and ICN could be interconnected. The authors support that still a lot of extra research has to be done on the specific topic. Another issue that Mendonca et al are covering is the heterogeneous network support as mentioned above as well. Due to the constant increase of the mobile devices connected to the global web and the unstructured network that are creating between them, the authors state that the SDN technology can play a major role in the administration and orchestration of these networks. The OpenRoads project that was mentioned in a previous subchapter is part of this domain's research (Yap, et al., 2010).

2.4.5 Answer for Sub-Research Question 1.2

Having analyzed sources from academia and industry that focused on the trends and evolution of SDN, the second sub-question can be answered based on the recapitulation of the gathered information.

> **Sub-Research Question 1.2:** *Which are the future trends of SDN?*

There are many innovative startups in the domain of SDN that are marketing cutting edge technology implementations. They are aimed at producing pure switches, virtualizing all of OSI's layers in an all-in-one new technology and are exploiting, exploring and utilizing open standards and open projects for their own good and growth. Additionally, based on SDN market analysts, SDN is one of the top 10 disruptive technologies to have impact in the industry for at least the next three years. The SDN market will grow to $2.45 billion till 2018. And the biggest concerns of the potential SDN adopters are network security issues, migration costs and lack of proof of reliability. So it is supported that the broad adoption of SDN technology might take more than ten years. Finally, academic researchers are exploring the capabilities of SDN in every possible direction. And they support that the need of a multiple controller systems is really important and can help the adaption of SDN from the market. Since it will solve the current issue with the single point of failure of the current single controller implementations. Academics are also are making clear that the need of large scale real life SDN implementations is of a great importance, so that more and more companies will trust and adopt the technology based on network externalities effects.

2.5 Conclusions

The two sub-research questions have been answered and so did the first main question through them. To recapitulate, SDN is currently still in its early adoption phase and OpenFlow is the dominant enabling protocol. Moreover, there are many different SDN controllers in the market and much more are the nonproprietary projects that big established infrastructure vendors support. Use cases of SDN are focusing on: network management and availability, security assurance and innovative wireless implementations. The diffusion of SDN technology for the entire market is yet to come. The future of the SDN technology is forecasted to be full of new developments that will be open source oriented. The SDN market is constantly growing and the academia is eager to keep exploring and exploiting the domain.

At this point the second chapter of this master thesis is completed and as it can be seen in the following figure as well, in the next chapter will take place the business model frameworks' literature review. Scope of this literature review is the advancement of the scientific domain of business model frameworks and the answering of the second research question that is looking for an answer in which is the business model framework that best supports the SDN business model design.

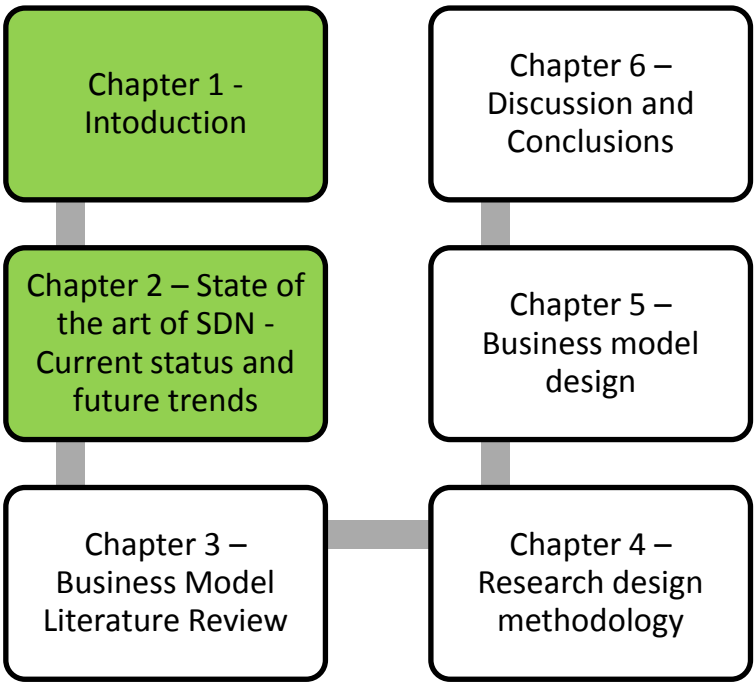

Figure 7 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

3 Chapter 3. Business Model Literature Review

3.1 Introduction

In the third chapter of this master thesis an in depth review of different business model frameworks is made in order to give answer to the *second research question*:

> ***Research Question 2:*** *Which business model framework best supports the design of an SDN business model?*

In order to have a rationalized answer to this research question a comparison of three popular business model frameworks is made. Although, objective of this master thesis is the design of a business model based on the SDN technology and not the creation of a business model framework survey. So the analysis of three frameworks is regarded satisfying to answer the second research question.

The three business model frameworks that are analyzed are Canvas, VISOR and STOF. Regarding to the definition of what a business model is, there are many definitions given and it is still under discussion of who was the first to use the term. Moreover the term business model is well known under other equivalent terminologies such as business concept, strategy, revenue and economic model (El Sawy & Pereira, 2013). There are various definitions for the business model term, but some of them that are multiple times cited are the following:

1. How a firm delivers value to customers and converts payment into profits (Teece, 2010).
2. Business model is a mechanism for turning ideas into revenue at reasonable cost (Gambardella & McGahan, 2010).

As for the definition of how value is created in electronic business, it is defined in the paper of (Amit & Zott, 2001). The authors argue that sources for value creation are: efficiency, novelty, lock-in effects and complementarities. In more detail, efficiency refers to minimization of costs per transaction, novelty is related with the innovativeness of the offering, lock-in is associated with the willingness of the customer to repeatedly use the service and complementarities are interconnected with bundling of services.

3.2 Review of Business Model Frameworks

Each one of the three business model frameworks is having its own strengths and limitations as well as special features that can help the designer of a business model when used under the right context. The conceptual model of each one of the frameworks is analyzed and the definition of the business model term is cited accordingly to the research of each author. Each separate framework analysis is concluded with the commenting of each business model framework in accordance with the attributes that (Zolnowski, Semmann, & Böhmann, 2011) regard as essential for service business model frameworks. The commenting is depicted in separated tables as well. When all of the three analyses are completed, a comparison is made in line with the attributes that are analyzed through the review of the three distinct frameworks. So the three individual tables are concatenated into one

in order to be compared with each other. This comparison helps to highlight which is the business model framework that will be further used for the implementation of the required SDN enabled business model.

As for the five criteria to be used in the comparison and evaluation of each one of the business model frameworks, they are the following and are separated in two categories, the generic and the service-specific category.

Generic attributes:

1. *Applicability*, refers to the ability of the business model framework to be utilized under different business logics. For example, a framework can have universal applicability or just applicability for services or even more precisely for IT services. In our case we seek for a business model that focuses in IT services design.

2. *Complexity*, the complexity of a framework as Zolnowski et al support has to be low in order to allow the designer to understand it in depth as well as easily use it. Of course for our case easiness of utilization of the framework is desired as well, but still main driver is the completeness of it in the IT domain.

Service-specific attributes:

3. *Focus on value proposition*, the authors argue that essential for a business model framework is to make clear in its design process the value proposition element. This is really important for our design as well, since we want to have a clear value proposition that will attract the interest of customers and end-users.

4. *Co-creation*, Zolnowski et al cite (Gustafsson, Kristensson, & Witell, 2011) which support that co-creation takes place when the value is created by the customer that is using the service under a specific circumstance as well as influences the design of the service itself. This is important for the design of our business model too. We are interested to define the context of use of the designed service with accuracy and based on the needs of the focused market segment.

5. *Value in use*, refers to the value that is created with the exchange and it is related with the interaction of the customer with the provider. Moreover it is interconnected with the co-creation and the value proposition. This is an attribute important for the design of our business model as well and is going to be taken in consideration too.

3.2.1 Canvas business model framework (Osterwalder & Pigneur, 2010)

Definition

The definition given for a business model by (Osterwalder & Pigneur, 2010) is the following:

> *"A business model describes the rationale of how an organization creates, delivers, and captures value".*

Structure of the Canvas business model framework

The structure of the Canvas business model is consisted of nine blocks that cover four main areas of business. Namely these areas of business are *Customers, Offer, Infrastructure and Financial Viability*.

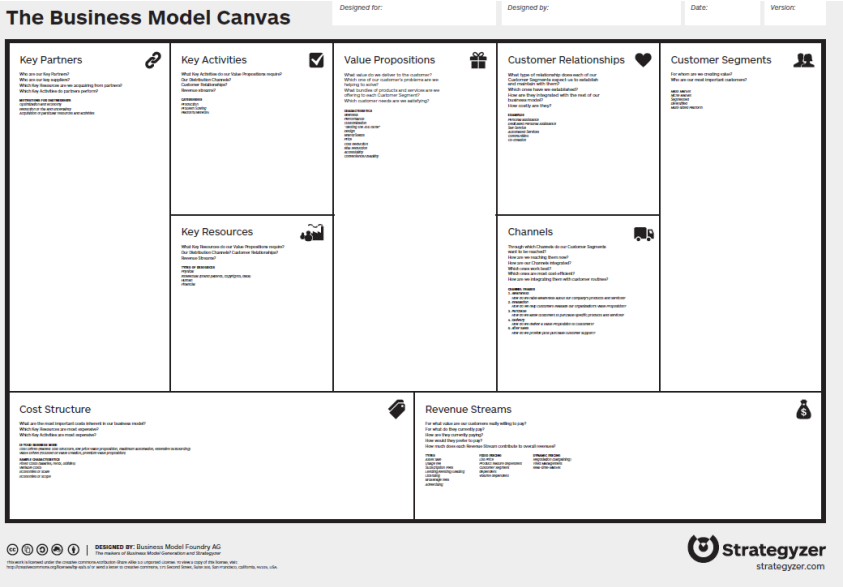

Figure 8 - The Business Model Canvas (Business model generation, 2014)

The nine building blocks of the Canvas business model are the following:

1. Customer segments

This is the building block that defines the company's targeted customers to be reached and finally served. A company can group the customers into segments of common needs and behavior and other qualities. It is very important for the company to make a proper decision of which customers segments to serve and which not, so the design of the business model will be based especially on the needs of these customers.

2. Value propositions

The value proposition block is the one that is relevant with the reasons that a customer will choose the products of one company instead of another. The value proposition can be either quantitative or qualitative; for example it can be the price of the product and the design of it. Some of the factors that are generating value are the newness of the product or service, its performance, its ability to be customized and of course the branding of the product.

3. Channels

The channels are defined as the ways that the customers can get aware for the product, the way that they can purchase it and the post purchase support. The author is making a distinction between direct and indirect channels as well as between owned and partner channels. More specific the customer can be reached by the owned channels of the company or by the channels of the cooperating partners of the firm.

4. Customer relationships

This block describes the specific relationships that a company establishes with every customer segment that serves. More specifically it has to do with terms of personal assistance, self-service,

automated services, communities and co-creation. These factors are relevant with the customer retention and acquisition as well as with the enhancement of sales.

5. Revenue streams

The nametag of this block is almost self-explanatory and has to do with the price that the customers are willing to pay for the product as well as the fees that the company is charging for usage of the products and services, the subscription fees, the licensing and renting or leasing of equipment and products.

6. Key resources

The key resources are referring to the physical, intellectual, human and financial competencies of the firm that are enabling it to mobilize in the market. It is the building block of the model that makes clear which are the key resources needed to make the model work as supposed to.

7. Key activities

This is the building block that defines the most important processes that should take place in order to enable the functioning of the intended business model. Key processes are the production of the products, the problem solving and the choices for which platforms and networks are going to be utilized by the value creation maximization of the business model.

8. Key partnerships

The key partnerships building block that has to do with the organization and the decision making of the key partners the suppliers in order to focus on economies of scale, the key partners that could lead to minimization of risks and uncertainties and last but not least the necessary acquisition of particular resources and activities.

9. Cost structure

The ninth building block includes all the costs that are made in order to have an operational business. These costs include the fixed and variable costs, as well as the intention for economies of scale and scope.

The 'Business Model Canvas'

A visualization of the Canvas business model can be seen on the following figure. The authors of the framework (Osterwalder & Pigneur, 2010) are supporting that the design of a business model is more efficient when the 'canvas' is printed so the ideas generated by brainstorming and collaboration are visualized on it based.

Comments

In his paper (Ballon, 2007), is mentioning that the Canvas business model is *"too focused on individual firms' corporate decisions".* The unit of analysis of the Canvas model is the individual firm and too much focus is given to the marketing of the product/service. Last but not least the canvas business model is a brainstorming tool that can be helpful for ideas generation but lacks of a framework to support the necessary action moves that have to be followed for the design of a viable business model as well as its robustness check. The lack of in depth analysis of multi-actor network

studies, as well as the neglecting of the service design and ICT as unit of analysis are major drawbacks of the Canvas framework. On the other hand Canvas has a detailed and structured design process as an outcome of its nine building blocks. Plus the business model canvas is a tool that adds value to the designers of a business model. Based on these comments as well as the review of the framework the table for the comparison in filled as seen on the next table.

Attributes / Framework	*Applicability*	*Complexity*	*Focus on value proposition*	*Co-creation*	*Value in use*
Canvas	Generic	Low	Yes	No	No

Table 2 - Canvas framework alignment with needed factors

3.2.2 VISOR business model framework (El Sawy & Pereira, 2013)

Definition

(El Sawy & Pereira, 2013) are not giving specific definition for the term business model, but they are mentioning the most common ones based on an in depth literature survey. Additionally in the second chapter of their book they make explicit the need for business models oriented to IT services, as the role of IT is enhanced in the business domain.

Structure of the VISOR business model framework

The VISOR business model is consisted of five main components which are creating the acronym of the business model: ***V****alue proposition,* ***I****nterface,* ***S****ervice Platform,* ***O****rganization Model and* ***R****evenue Model*. These five components are divided into two sub-categories. The real value proposition and the real cost of delivery. In the real value proposition sub-category are included the value proposition and revenue model components, and in the sub category of real cost of delivery are included the rest of the components. VISOR's framework visualization can be seen in the next figure.

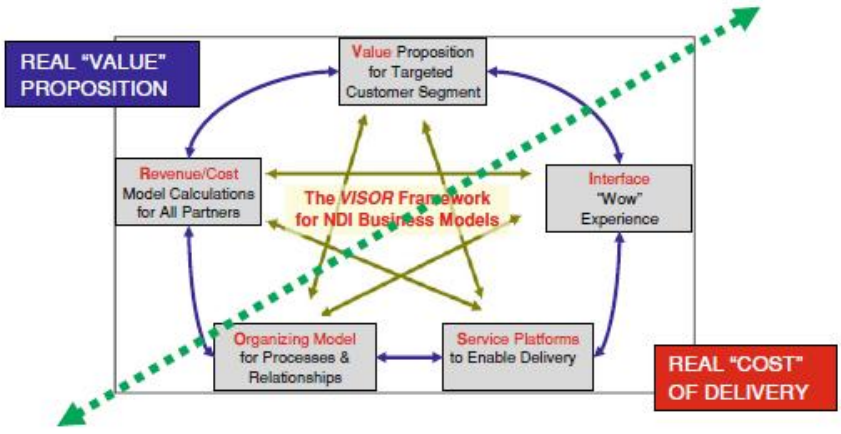

Figure 9 - The Visor Model (El Sawy & Pereira, 2013)

In the following paragraphs the five components of VISOR are briefly analyzed.

Value proposition

As in the canvas model, the VISOR as well, has an element that analyzes why a customer should choose a service of the specific company. So it is made explicit which is the added value and the

value proposition of the company's product/service to the customer. In this element the designer has to identify the value provided to the end user even if the company is not the last one to deliver the service to the customer, and is an intermediate in the value creation chain.

Interface

This is the component that includes all the success factors for the user interface experience. These factors are among other ease of use, simplicity and convenience. Of course in this component there are included the affordances and limitations of the technology that are giving the competitive advantage to the company or is creating barriers towards its way to it.

Service Platform

In this component of the business model there is made analysis of requirements for the needed IT platforms in order to ensure the non-problematic and even more value adding provision of the service to the customers.

Organization Model

As quoted by the author: *"Describes how an enterprise or a set of partners will organize business processes, value chains, and partner relationships to effectively and efficiently deliver products and services."* In other words this is the part of the framework that the stakeholder analysis for the sustainability of the model is made. It is important that at least the first tier of stakeholders are included in this analysis.

Revenue Model

This component of the business model makes sure that the revenues will exceed the costs and that this business model will lead to long term sustainability of the firm and its product/ service. Factors taken in account in this component among others are the user preferences, the prices that the consumers are willing to pay and the additional factors that are fluctuating the market and the pricing as well.

Comments

The VISOR framework focuses on the digital platforms - not services - and the new era of business models. It is making explicit that technology is integrated in the business model and focuses on how it generates value for the customer and the company as well. As for the evaluation of the design business model, the VISOR networks proposes the process of information system design theory (ISDT). The ISDT defines meta-requirements and meta-design that are to be defined and tested by the designer of the business model. The framework is providing the needed parameters for the design of a business model of technological concepts, but its abilities for further testing and evolution of the designed model are incomplete and not clearly defined.

Attributes / Framework	*Applicability*	*Complexity*	*Focus on value proposition*	*Co-creation*	*Value in use*
VISOR	IT Platforms	Medium	Yes	Yes	Yes

Table 3 - VISOR framework alignment with needed factors

3.2.3 STOF business model framework (Bouwman, De Vos, & Haaker, 2010)

Definition

(Bouwman, De Vos, & Haaker, 2010) are giving the following definition for a business model:

> *"A business model is a blueprint for a service to be delivered, describing the service definition and the intended value for the target group, the sources of revenue, and providing an architecture for the service delivery, including a description of the resources required, and the organizational and financial arrangements between the involved business actors, including a description of their roles and the division of costs and revenues over the business actors".*

Structure of the STOF business model framework

The STOF framework is focusing to analyze four distinct but still interconnected domains. As in the case of the VISOR business model framework, the STOF framework's name is an acronym of the domains that is analyzing. To be precise these domains are: Service, Technology, Organization and Finance. The four domains are going to be presented in the next paragraphs. As for the visualization of the STOF business model, it could be seen in the following figure. Last but not least, although that the model is focusing on mobile services, it has been applied till now in many other domains both by the academia and the industry as well. The STOF model is focusing on the service innovation and the development of new service ideas into functioning concepts, as the authors state in the second chapter of their book (Bouwman, De Vos, & Haaker, 2010).

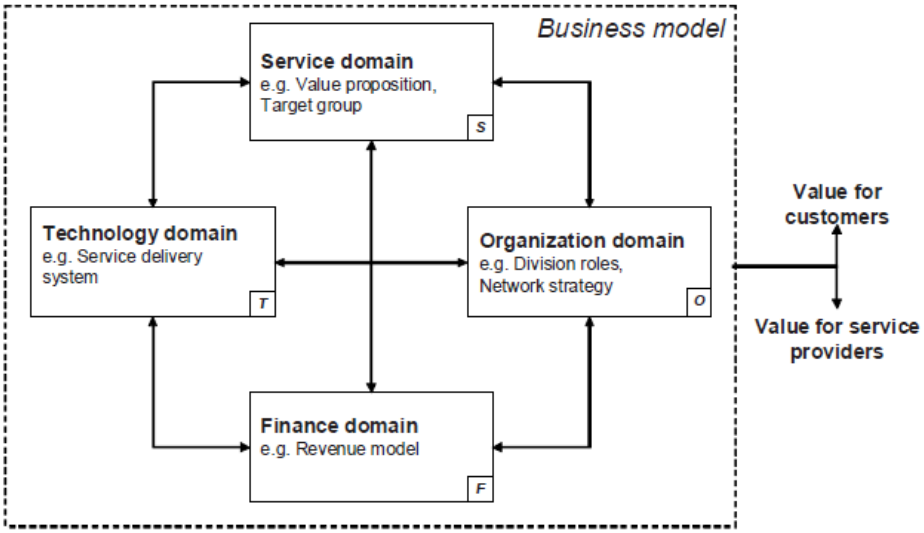

Figure 10 - STOF business model domains (Bouwman, De Vos, & Haaker, 2010)

Service domain

In the service domain the main issue discussed is the value creation. From the intended value that the provider of the service wants to offer to the client to the perceived value that the end user perceives. Additionally, special focus on the service domain is given on the context that the service is used and the effort of the end user when adopting the new service. More analytically the concepts for the service's design include: indented/delivered/expected/perceived value, the focused customer and end user, the context the service is used, the tariff and the effort and last but not least the bundling of services.

Technology domain

This domain is focusing on the enabling technologies and architectures that are necessary for the technology in order to be delivered to the customer. Additionally, issues of cost of the used equipment and the proprietary services used are made as well. Concepts that are taken in consideration for the design of the technology domain are: technical architecture, backbone infrastructure, access networks, service platforms, devices, applications, data and technical functionality.

Organization domain

In the organization domain there is analyzed the provisioning of necessary services from different stakeholders, which are distinguished in tiers. Furthermore, the value network or else web that is created in order to achieve the provision of the technology is analyzed in this domain as well. The concepts of the organization design consist of: actors, value network, interactions and relations, strategies and goals, organizational arrangements, value activities and resources and capabilities.

Finance domain

The financial domain analyses the capital needed, the costs for the implantation of the service the revenues from it and the involved risks. These four factors are important for the marketing of the service. The design of the finance domain requires the analysis of the following design variables: investment sources, cost sources, performance indicators, revenue sources, risk sources, pricing and financial arrangements.

Critical Success Factors and Critical Design Issues

Additionally, the STOF framework further than the design variables for each one of the four main domains, it has refinement variables to align the business model into a more desired state for the users and the rest of the involved stakeholders in general. The Critical Design Issues (CDIs) and the Critical Success Factors (CSFs) are the elements of the STOF framework that are responsible for this alignment of a sustainable business model designing. All of the additional design variables are referred on the next paragraphs.

Important to be mentioned as well is that the STOF model is having a predefined design algorithm that is consisted of four steps and the second and third of them are including the research of alignment with the CSFs and the CDIs. All four steps can be seen at the next figure.

Critical Success Factors

The CSFs are divided in two categories, the ones that are oriented in the creation of customer value and the others that are oriented in the creation of network value. The CSFs for customer value creation are: Clearly Defined Target Group, Compelling Value Proposition, Unobtrusive Customer Retention and Acceptable Quality of Service. And the CSFs for network value creation are: Acceptable Profitability, Acceptable Risks, Sustainable Network Strategy and Acceptable Division of Roles.

Critical Design Issues

The CDIs are focused on the four domains of STOF. So there are specific design variables for each one of the domains. These variables are going to be briefly introduced in the next lines. For the Service Domain the CDIs are: Targeting, Creating Value Elements, Branding, Customer Retention. For the Technology Domain the CDIs are: Security, Quality of Service, System Integration, Accessibility for Customer, Management of User Profiles. As for the Organization Domain's CDIs these are: Partner

Selection, Network Openness, Network Governance, Network Complexity. Last but not least, for the Finance Domain the CDIs are: Pricing, Division of Costs and Revenues, Valuation of Contributions and Benefits.

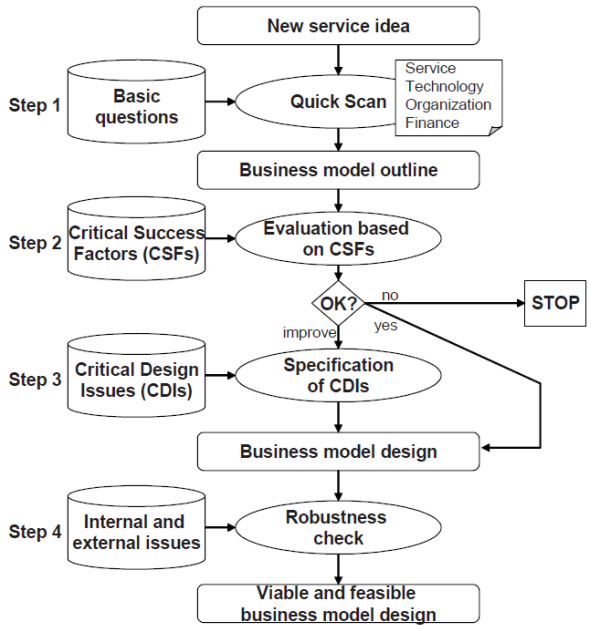

Figure 11 - Design Steps of the Business Model design based on STOF framework's methodology (Bouwman, De Vos, & Haaker, 2010).

Comments

The STOF framework is focusing on ICT applications and service platforms. Additionally, through the framework is made an in depth analysis of involved stakeholders, their value network and ecosystem. Additionally, STOF framework is design oriented and has advanced tools for further development of a business model. Critical Design Issues and Critical Success Factors are provided in order to guide the design of viable business models. This is its 'competitive advantage' compared to the VISOR model. STOF enables the researcher to make use of "stress tests" and decision support tools for the testing of alternative business models. This completeness of the STOF framework is giving it a competitive advantage compared to the other two frameworks that were analyzed in this chapter.

Attributes / Framework	*Applicability*	*Complexity*	*Focus on value proposition*	*Co-creation*	*Value in use*
STOF	(Mobile) IT Services	Medium	Yes	Yes	Yes

Table 4 - STOF framework alignment with needed factors

3.3 Answer for Research Question 2

In order to make more structured and more rational the process of giving an answer to the second research question, all of the gathered information of this chapter is going to be summed up in this section. Some additional information that would help this process is going to be added too. A table

containing the three analyzed business model frameworks is designed too. This table includes the discussed attributes that are regarded important for choosing the appropriate business model framework and give an answer to the second research question.

Attributes / Framework	*Applicability*	*Complexity*	*Focus on value proposition*	*Co-creation*	*Value in use*
Canvas	Generic	Low	Yes	No	No
VISOR	IT Platforms	Medium	Yes	Yes	Yes
STOF	(Mobile) IT Services	Medium	Yes	Yes	Yes

Table 5 - Comparative business model framework table

As already stated, some of the frameworks are indented for general use and some others are focusing in ICT domain. VISOR and STOF are focused on ICT and Canvas is having a more general perspective for any domains implementation. Much more, STOF is the only framework that is focused in the design of services. On the contrast, VISOR is focused on platforms and Canvas is designed to support implementation of more general and tangible concepts, where technology is not of a major importance.

Additionally, the focus on networked enterprises is an important factor for the comparison as well and it is interrelated with the co-creation and value in use. An IT service provider is an enterprise with many stakeholders and there is need for including them in the analysis. Canvas is focusing on a sole firm and by default is completely neglecting this viewpoint. But STOF and VISOR are focusing in the value networks around the main firm and because of this they are having a more complete perspective on the design of the network's value creation. As for the complexity of each framework, all of them are having a detailed and structured design process, but some are more detailed in the validation phase. Canvas can support brainstorming through its nine domains but after this stage there is no structured way to keep improving the business model in order to secure its viability. VISOR proposes the process of information system design theory (ISDT), but still lacks the same features as Canvas. As for STOF business model it is having a clear structure for the refinement of a designed business model through four individual steps, which are accompanied by the checking of critical success factors and critical success issues.

On the other hand, the authors of the frameworks have worked on additional framework tools that enhance a business model's design and make the process less complex. Canvas is providing some added value to the designer of a business model with its "Canvas" that is indented to be printed and filled in during brainstorming sessions. And STOF is having a supplementary workbook that is advising of how to utilize the model plus a stress testing tool that assists the complete design process of a business model. But VISOR is not having any additional features to support the design of a business model.

After this long analysis we believe that the second research question could be rationally answered.

> **Research Question 2:** *Which business model framework best supports the design of an SDN business model?*

Following up the analysis and comparison of the three frameworks of Canvas, VISOR and STOF, it gets clear that the most appropriate business is STOF. It is a framework that is focusing on value networks and ICT services. It is designed for service innovation and business models design as well as it has a structured process to enhance the sustainability of a model. Additionally STOF is making use of the CDIs and CSFs. All the additional tools of STOF framework are helpful for the designer.

Much more, STOF aligns with the proposition of Casadesus-Masanell and Ricart (Casadesus-Masanell & Ricart, 2011). They support that there are three characteristics that every good business model should have. These three characteristics are: alignment of business model with company's goals, self-reinforcing business model and robustness of it. STOF framework through its four design steps is allowing the design of a good business model something that enhances the rationale for its choice.

So all these reasons make us support that STOF is the framework that best supports the intended SDN service's design. So, STOF business model framework is going to be used as the fundamental framework for this master thesis research project.

3.4 Status of thesis project's progress and next chapters

With the answer of the second research question, the third chapter is completed. Its logical extension is the fourth chapter, which includes the research design description of the master thesis project. On the next figure can be seen the progress of the research up to this point, as well as the next steps that are to follow up.

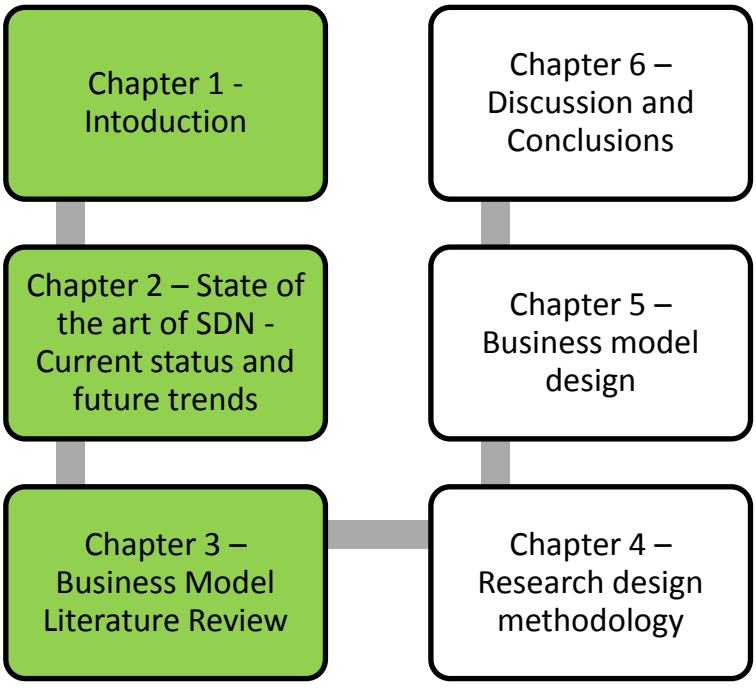

Figure 12 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

4 Chapter 4. Research Methodology

4.1 Introduction

In this chapter is analyzed the research methodology that is followed for the design of the SDN based business model. Plus, the general methodology of design of the entire master thesis project itself is analyzed in this chapter as well. So in the next paragraphs is made clear which research methods are used as well as which design methods are utilized in order to ensure that a robust and sustainable business model is the outcome. As discussed in the third chapter, the business model framework that is chosen for the design of the SDN business model is the STOF framework of (Bouwman, De Vos, & Haaker, 2010).

4.2 Structure of master thesis

The structure of this thesis is based on the methodology of design science research described in the book of (Vaishnavi & Kuechler, 2007), which focuses on ICT design science research issues. The authors support that there are five stages in every research related with information and communication technologies. These stages are: Awareness of Problem, Suggestion, Development, Evaluation and Conclusion. In the next figure these five stages are presented in a flow chart. The flow chart represents the logical continuation of our research's stages and emphasizes the fact that iterations for improvements can be made during the whole process. The authors add that iterations are easier to be implemented in the early stages of the research, since not much progress has taken place and alterations would not affect much the already made research. In the third column of the chart the corresponding chapters of the thesis to each step of the process are visible.

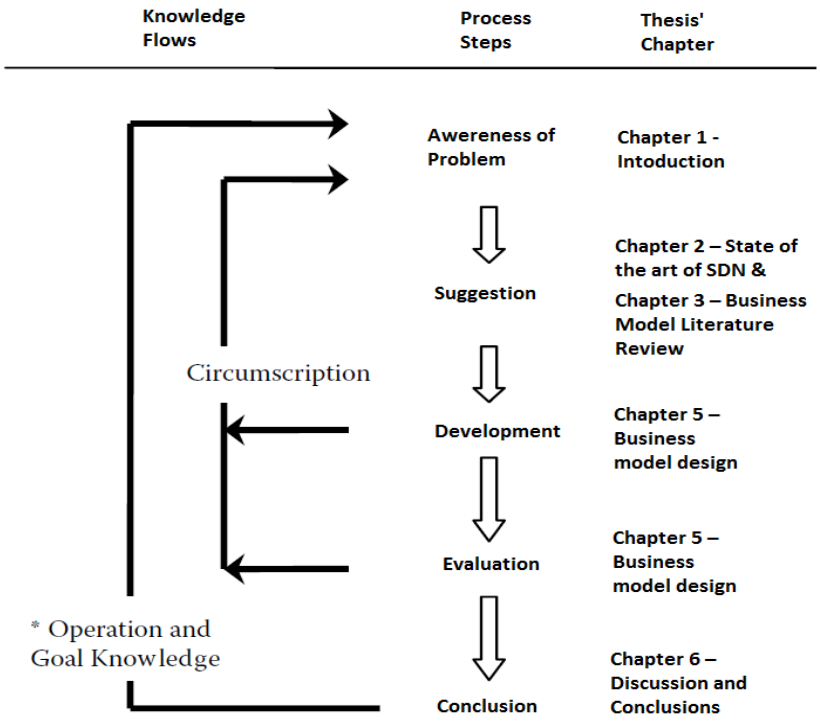

Figure 13 General methodology of design science research (Vaishnavi & Kuechler, 2007)

4.2.1 Awareness of problem

The first stage where the awareness of problem is made, is incorporated in chapter one of the thesis. In the first chapter the problem definition is made clear and the research questions are formulated as an outcome of the stage. So the novelty and the deriving uncertainties of SDN are stated and the fact that there is lack of business model literature on the domain of computer networks is stretched too.

4.2.2 Suggestion

The suggestion of the problem's solution is given in the second and third chapters of the thesis. In the second chapter the novel concept of SDN is explored based on its current and future trends. And in the third chapter answer is given for which is the best business model to be used in this master thesis. Outcomes of the suggestion stage are the state of the art of SDN and the choice of STOF business model framework for the support of the business model's design.

4.2.3 Development

With the development stage is related the fifth chapter of the thesis, where as an outcome the first three steps of STOF framework are exploited for the design of the SDN enabled business model.

4.2.4 Evaluation

The evaluation stage is the fourth step of STOF framework and is incorporated in the fifth chapter of the thesis as well. Robustness check of the designed business model is made and outcome of it is a viable and feasible business model.

4.2.5 Conclusion

This is the last stage of the research methodology and the last chapter of the master thesis as well. The conclusion stage is included in the master thesis with the sixth chapter that includes the discussion and conclusions. Outcome of the conclusion stage is the successful completion of the master thesis and the answering of all research questions.

4.3 Research design of SDN business model

This master thesis makes use of *qualitative exploratory methods* and its business model design is based on the design steps of STOF framework as is presented in the fifth chapter of the book of (Bouwman, De Vos, & Haaker, 2010).

The research for the design of the business model is based on a case study and more specific a *single case study* with *unit of analysis* the desired business model (Yin, 2009) (Verschuren, Doorewaard, & Mellion, 2010). The choice for the *single case study* is made based on the following reasons:

1. There is only one case and it is difficult to gather and analyze quantitative data for it.
2. The intention of the research is to focus in depth and not in breadth.
3. The utilization of a case study will allow the research of the business model as a whole in a holistic view.
4. The case study research methodology is based on onsite research; interviews and literature desk research.

4.3.1 Business Model design

As for the third research question, the design of SDN business model is based on the design steps of STOF framework. However, some alterations have been made in order to adopt the framework in the

needs of this master thesis research project. (Verschuren & Hartog, 2005) are proposing a specific *design cycle* for the *design oriented researches*. And as stated in the first chapter already, this master thesis' scope is to design a business model enabled from SDN through exploratory research. So the design cycle of Verschuren and Hartog can be applied to the design of our business model in order to make it a scientifically structured process that can be tested and evaluated.

The design cycle of Verschuren and Hartog is including six consecutive steps that are leading to the desired model. More specifically, first step is the first hunch, where the goal [G] for the design of the business model is set. Then is the step for the definition of requirements [R] and assumptions [A]. These two elements are having three sub-categories each. These sub-categories are: functional requirements [Rf] and assumptions [Af], user requirements [Ru] and assumptions [Au] and contextual requirements [Rc] and assumptions [Ac]. Next step is the definition of the structural specifications [S] that is founded on the assumptions and requirements of step two. Later on comes the step of prototyping. In this step the SDN business model is designed on theoretical level according to our case study. Following steps are the implementation step and last - sixth step is the evaluation of the designed artifact. Our research will skip the design cycle's fifth step that includes real life implementation of the business model. Due to limitations in time and finance for research and development the implementation of the business model in real life is regarded not to be in the scope of this thesis. As for the evaluation of the designed business model, which Verschuren and Hartog propose that should be the last step, we implement it as the fifth and last step of our design.

Through the next lines each of the four design cycle steps will be analyzed and in detail analysis for their implementation is given.

First hunch - Goal [G]

Goal [G] of our design is to design a *business model for SDN services that can be served from an IT service provider to its clients*. In any case, one of the main research objectives of this master thesis is the design of a business model that is enabled from the SDN technology. Preparatory chapters for the achievement of the goal are the second and third chapters of the master thesis. In these chapters exploratory in depth research is made first for the technology domain of SDN and secondly for the business model framework domain. While in the first introductory chapter of the thesis, more information is given for the background and reasoning of our research.

Requirements [R] and Assumptions [A]

The requirements scope to achieve the set goal, as we discussed already there are three types of requirements: functional, user and contextual. We have recognized six requirements for our design. The exploitation of the SDN technology and the value creation for all the involved stakeholders are the most important ones as the functional requirements of our design. Plus we have as requirements for the business model design: enabling of completive advantage, lowering of costs, alignment of the business model with the strategy of the company and its stakeholders, and last but not least the maturity of SDN as contextual requirement. Moreover, we recognized six assumptions that are vital for our design: integration of SDN in the datacenters of IT provider, adequate resources for SDN's R&D from the IT provider, knowledgeable on SDN employees within IT provider, will for risk-taking from IT provider and maturity of SDN in long term. By making sure that theses [Rs] and [As] are incorporated in our design, we are getting one step closer to have a viable and feasible business

model. And as discussed in the introduction of this section, all of the requirements and assumptions are transferred in the structural specifications of our design.

Requirements [R]			Assumptions [A]		
Functional [Rf]	User [Ru]	Contextual [Rc]	Functional [Af]	User [Au]	Contextual [Ac]
Exploitation of SDN	Enable competitive advantage	Need for SDN to mature and be a proven concept	SDN is integrated in the datacenter of the IT service provider	IT service provider has adequate resources to invest, research and develop SDN in its datacenter	SDN will mature and become a proven concept in long term (approximately 5 years)
Deliver value to all stakeholders	Lowering of costs			IT service provider's engineers are trained on SDN	
	Business model aligned with the strategic goals of IT service provider as well as its partners and customers			IT service provider is willing to take risks and innovate based on SDN	

Table 6 - Table of design requirements and assumptions

Structural specifications [S]

The structural specifications are deriving from the requirements and assumptions we are making on the previous design step. Much more, the structural specifications are incorporated in our design as part of the business model framework. The critical design issues (CDIs) and critical success factors (CSFs) of STOF framework are serving this purpose. Both of them are analyzed in the next lines.

Prototype

The prototype of our design is based on STOF framework as well. The way that we are deriving to the prototype is analyzed through the next lines as well.

Evaluation

The evaluation of our business model is realized with the fourth and last step of STOF framework. Of how this is achieved is discussed through the next sections.

STOF framework customization

As for the framework and the final form of it as it will be utilized, the original and the altered versions of the it can be seen at the next figure. The main differences is the exclusion of the "if condition" after the execution of the second step. This differentiation is made due to the novelty of the SDN technology that can be translated into high uncertainty that makes difficult to predict the future of the service. Consequently, stopping of the service's design at an early state like this wouldn't be the optimum decision.

So the design of the required business model will be made based on the *right flow chart*.

Additionally, prior to the design of the required business model, a *quick scan of the existing business model* of the IT service provider will be made. Based on the 13th chapter of the STOF framework book of (Bouwman, De Vos, & Haaker, 2010), it is helpful if in the first place a successful similar business model is studied and fitted in the four domains of STOF framework. This is the starting point for our novel business model. Knowledge for the current business model is acquired by a semi-structured interview with a highly ranked manager of the IT service provider. Additionally, information deriving from the official website of Capgemini's Infrastructure Outsourcing department provided us with more information and advanced the current business model's identification process.

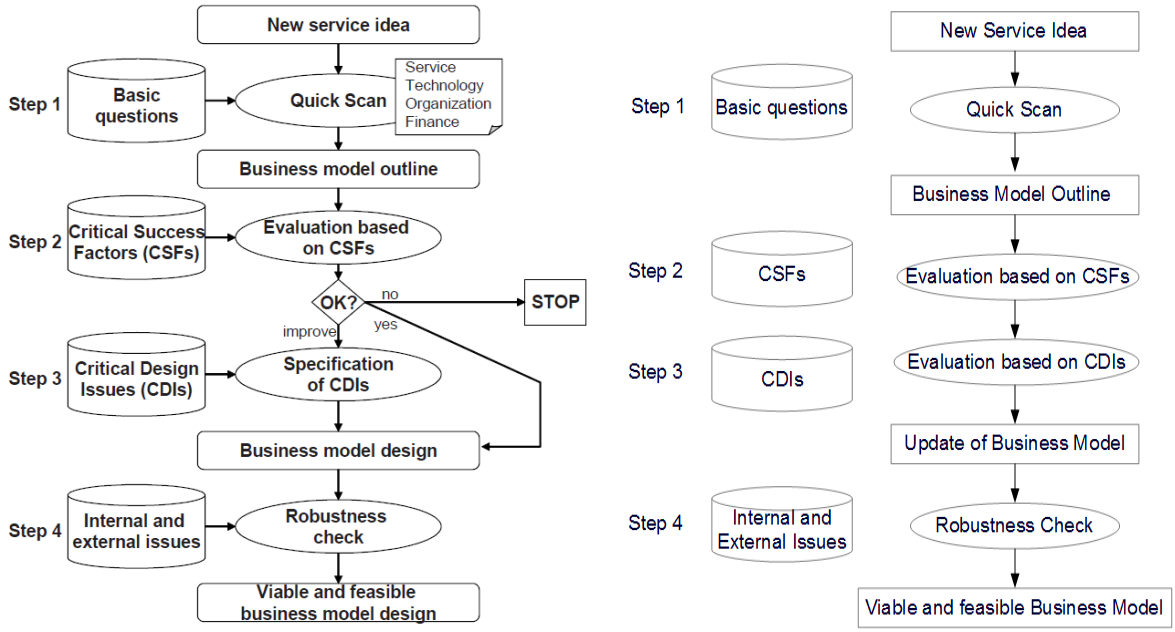

Figure 14 - Design Steps of the Business Model design based on STOF framework's methodology (Bouwman, De Vos, & Haaker, 2010). On the left is the original design and on the right is the altered one for the needs of this research.

Back to the design of the desired SDN based business model again, as seen in the upper figure, **first step** is the quick scan of STOF framework's four domains.

In the **second step** the chosen CSFs are utilized for the update of the business model. And on the **third step**, the chosen CDIs are utilized in order to make the model closer to be feasible and viable. The CDIs that will are utilized for the refinement of the business model are a logical continuation of the chosen CSFs from the second step of design process. As seen in the upper figure as well, STOF's framework is based on the continual refinement of the business model's design based on the chosen CSFs and CDIs.

On the fourth and **last step**, the robustness check for the designed business model is made. Probable risks for the new service are recognized and risk mitigation strategies are made for them. Outcome of the fourth step is the finalized viable and feasible SDN business model.

Methodologies used in each one of STOF framework's design steps

Step 1 – Quick Scan

Initially for the first step of the service's design, which has as an outcome the "quick scanned" version of the business model, is based on literature desk research for required academic theories

and technical information related to SDN. Moreover, the gathered information from the second chapter of the thesis that is related with the use cases of SDN technology is taken into account in order to be turned into services that will be provided by the IT service provider. Afterwards semi-structured interviews with specialists, internally and externally of the IT service provider's organization are executed.

The *internal* interviews are executed with technical managers of the IT service provider that are familiar with the provisioning and designing of services based on Capgemini's Infrastructure Outsourcing capabilities in combination with the requirements of the users. These interviews are semi-structured and mainly focus on the understanding of the needs of the market as well as the requirements and capabilities of the company when designing a new service. Additional interviews are contacted with managers of the IT service provider that are responsible for the sales of services of the IT service providing company. They are familiar with market's and customers' requirements and their insight is helpful for this research. To conclude, the internal interviews help to frame the requirements of the service, as well as the capabilities and strategy of Capgemini.

As for the interviews that are arranged with *external* parties, firstly they are held with existing customers of the IT service provider. Their point of view for the use cases of SDN technology will be taken into account in order to use only the useful for them ones. Customers' input provides information for which of the use cases of SDN are attractive for the market's needs, and of how it is expected that SDN technology can serve these needs. Additionally, semi-structured external interviews are contacted with computer network infrastructure vendors that help by providing insight in the technical solutions as they propose their own SDN solutions. Plus they give their own perspective regarding the needs of market. Vendors also provide an insight of how they position themselves in the value network and the organization of the service's provision.

Step 2 and Step 3 – Critical Success Factors and Critical Design Issues

The next two steps of the business model's design are based on internal interviews as well. Scope of these interviews is the refinement of the business model's quick scanned version that derives from the chosen CSFs and CDIs, based on the context of prior and current step's interviews.

Semi-structured interviews are carried out with employees of the IT service provider, the opinion of which is asked for the improvement of the business model based on the CSFs and CDIs. Furthermore, they provide knowledge on the trajectory of the technology, the use cases of it that are of a great importance for industry and the ways that the designed service can be better implemented.

Step 4 – Robustness check

On the fourth and last step, an internal interview with a senior employee of the IT provider takes place. Scope of this last interview is to finalize the business model by recognizing potential risks deriving from itself as well the necessary strategies to mitigate them. Moreover with this concluding internal interview, there is given the possibility for the evaluation of the designed business model. So that the expert of the IT service provider can evaluate the business model's state and give his opinion for updates that could possibly help the viability and feasibility of it (Bouwman, De Vos, & Haaker, 2010).

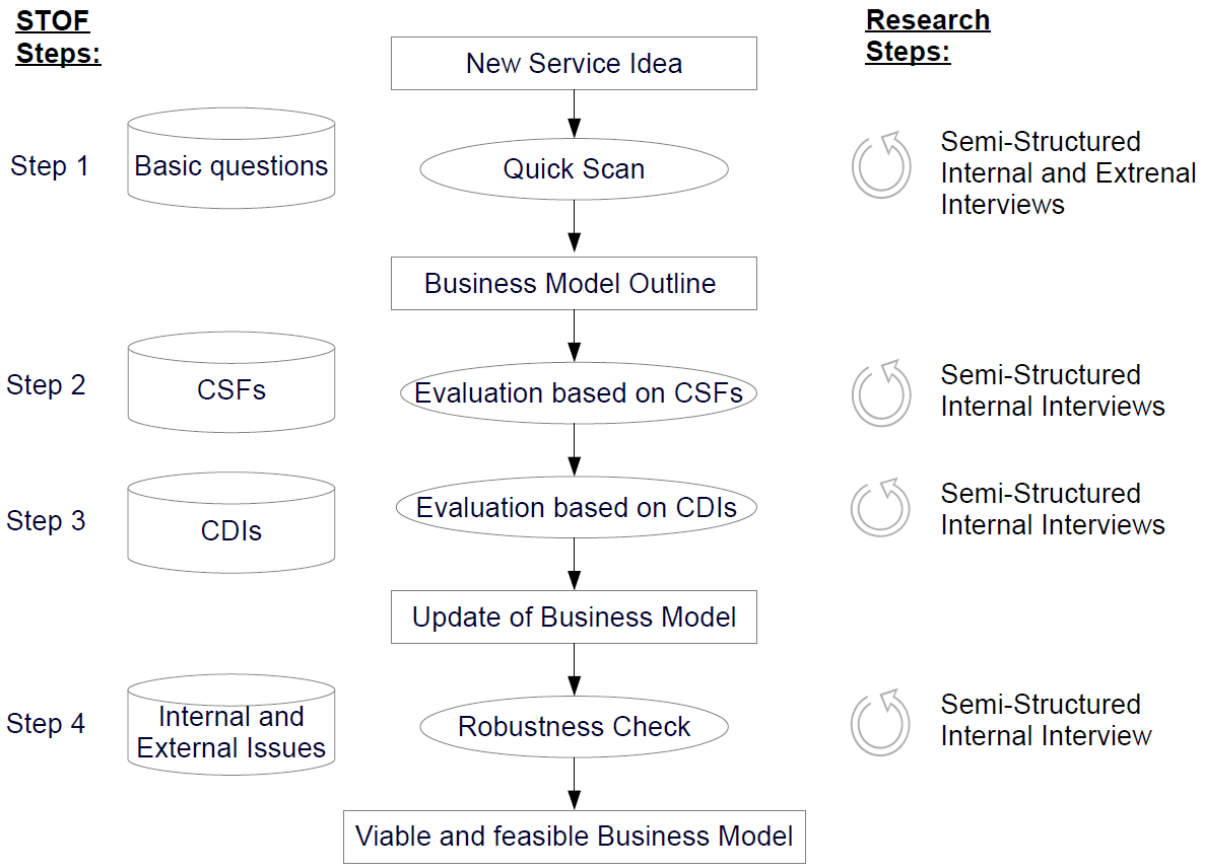

Figure 15 - Research Methodology per step of STOF model

Analyzing and verifying the qualitative data of interviews

For the analysis of the interview data the *thematic narrative analysis* is used (Smith, 2000). And regarding the *verification* of the interviews' data, the method of *participants' validation* is practiced. This means that after the interviews are conducted, they are transcribed/summarized and they are send together to the according interviewed person in order for him to validate of whether or not the outcome is accurate and as indented to be during the interview (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008). Additionally, in order to ensure the privacy of all participants – interviewees all the interviews are anonymized. The anonymity is applied mainly for two reasons: firstly, for the protection of interests of companies and secondly to allow the interviewees to freely express their opinions.

STOF business model framework parameterization

The elements of STOF business model framework that are going to be utilized for this master thesis will be analyzed in this section. STOF as seen in the third chapter of this thesis, is a comprehensive framework that incorporates in its design process multiple design parameters. In this sub-chapter is made clear which are the elements that are analyzed in each of the four domains of STOF, as well as which are the Critical Design Issues (CDIs) and the Critical Success Factors (CDFs) that are taken into account for the design of the SDN based business model.

Quick Scan

For the quick scanned version of the business model almost all of the elements of the four domains of STOF framework are researched and filled in. More focus is given on the domains of service and

technology. The complex construct of SDN technology is investigated in depth and the way that the service is implemented is assured. Additionally, the predefined complex corporate structure of Capgemini is not allowing high margins of experimentation so the organizational domain is not analyzed in depth. As for the finance domain, it is analyzed more on qualitative basis since scope of the thesis is not the financial analysis of Capgemini's datacenters nor the detailed pricing of the designed service.

Critical Success Factors (CSFs) and Critical Design Issues (CDIs)

The rationality for the chosen CSFs is analyzed for each one of the factors separately. For the choice of them the critical thinking of the authors was utilized, as well as the design requirements and assumptions are turned into structural requirements with the use of CSFs and CDIs. Much more, the internally and externally conducted interviews of the quick scan step give an indication of what is important for the customers and the company itself too. Additionally, the CSFs are inspired from the book of (Bouwman, De Vos, & Haaker, 2010) as well as from the practical guidelines for the STOF framework from the book of (Faber & de Vos, 2010). So taking into advance the above factors, the following CSFs are selected to formulate our business model.

The Critical Success Factors that are used for the design of the business model related with *creation of customer value* are:

1. clearly defined target group: this is a very important factor for the success of our business model, and most probably for the success of any other business model in general (Bouwman, De Vos, & Haaker, 2010). The focus of the target group is made clear already from the quick scan step of the business model, although after designing the first hunch of the service there is need to redefine the designed model. And this purpose is of course served from this specific CSF.

2. compelling value proposition: the CSF of compelling value proposition is following the same rationality as the previous one of the clearly defined target group. The value proposition is defined in the first stage of the design, but afterwards on the later steps when more information is accumulated, the need of redefining it becomes evident.

3. acceptable quality of service (QoS) for the customer and the end user: this CSF is deriving from the need of the users and customers of the service to have a well-functioning service. And much more a service that is worth the capital that is invested in it for its development and purchasing as per each actor (II1)&(EI2).

For the *creation of network value* are used the following critical success factors. All of them are chosen based on the abovementioned criteria as well. More specifically, for each one of them:

1. acceptable risks: in order for a business model to be viable, its risks shall be acceptable from all the involved actors. Additionally, the risks have to be balanced by the added value that will they will offer to the actors when taken (Bouwman, De Vos, & Haaker, 2010). Much more, the factors will be in a better balance with the viability of the business model when it will be aligned with its matching CDIs in order to reshape the business model.

2. acceptable division of roles: As with the case of the acceptable risks, the acceptable division of roles is necessary for the balancing of the business model and its enabling to be viable. In more detail, this factor is to check if all the necessary actors are included in our design and if it is needed to

add any extra or remove already introduced ones (II5). So in order to achieve this the CSF of acceptable division of roles is taken into account in our design.

3. lowered or at least same level prices for the services: this CSF is deriving from the requirements of the company's customers. During our interviews with customers, they explicitly mentioned that they are not willing to pay more for SDN services and much more they added that it would be good for them to pay less if possible, since IT is a commodity nowadays (EI1) & (EI2).

Based on the chosen CSFs the related with them CDIs are analyzed as well in order to update the business model. The CDIs are allowing us to redesign our business model and improve it as to be closer to a viable form. More specifically, all of the CDIs for the chosen CSFs are presented in the following table. For this step the books of (Bouwman, De Vos, & Haaker, 2010) and of (Faber & de Vos, 2010) are consulted in order to choose the best fitting CDIs for our model, always in alignment with the outcomes of the conducted interviews.

CSFs / CDIs	clearly defined target group	compelling value proposition	acceptable quality of service	acceptable risks	acceptable division of roles	lowered service prices
	targeting of customers	bundle composition	security	acceptance of a non-proven technology	network complexity	automation of processes
		services integration	delivered value	technology robustness enhancement	actors selection	internal re-organization

Table 7 - CSFs and CDIs

Sampling method, protocol and analysis of interviews

Interviewees' sampling method

Different senior employees from the IT service provider company i.e. Capgemini, are interviewed based on their expertise. Senior employees from organizations that are in the value network of the business models are interviewed based on their expertise as well. All of the participants are selected having in mind *purposive expert sampling* (Tongo, 2007). For example, when the technology of SDN is discussed, the interviewees are computer network experts with many years of experience in the domain. And when the financial perspective of the business model is discussed, then employees that are having experience in financial, service delivery and management processes and issues are interviewed to give their insight.

So the "quick scanned" business model is designed, discussed and evaluated (Ammenwerth, Iller, & Mansmann, 2003)& (Denzin, 1970) with the help of the 12 participants – interviewees of our research. A table containing analytical information for each one of the participants is given after these paragraphs. Moreover, as stated by (Verschuren, Doorewaard, & Mellion, 2010) the external validity of research projects based on case studies might be *"under pressure"*; because of the in depth research of a specific domain and the loss of focus for its generalization. This issued is mitigated by our research's design structure that entails interviewing of many experts from different fields. As it can be seen at the following table as well, the hardware vendor's employees from the telecommunications industry that are interviewed are from different companies and different , so are the . Plus, the method of data *triangulation* is used throughout the design of the business model.

Which allows to evaluate the business model in its different design phases and update the sections that need to be arranged

Interviews' protocol

As noted in the upper section, all of the participants of our research are chosen based on their professional expertise. Additionally, special attention is given to choose participants that are having many years of experience in the IT sector. All of the interviews start with a brief introduction of our project and later on the interviewee has the opportunity to introduce himself as well. On average the interviews are arranged to last approximately an hour. Moreover, all of the interviews are taking place in the site of the interviewed person, whether he is located internally or externally of Capgemini. Except from one interview that the interviewee is located in the U.S.A. and a teleconference platform is used to bridge the distance between Netherlands and U.S.A.. The locations that all of the interviews took place in Netherlands can be seen at the following map figure.

Furthermore and as mentioned in this chapter already, the interviews are semi-structured and the agenda of open ended questions is always followed during the process. Of course at some points that there is overlapping of information, on the spot changes can be made in order to maintain the natural flow of the conversation (Creswell., 2012). Most the interviews are focusing only in one of the four domains of our business model each time, always based on the expertise of the interviewee and in alignment with our research's needs. For each domain the same questions are asked all of the different interviewees. Last but not least, all the interviews are recorded and brief notes are taken during the process. Whereas later on the interviews are summarized and transcribed and the participants validation is requested.

Interviews' analysis

For the analysis of the interviews' data the *thematic narrative analysis* method is used (Smith, 2000). More specifically, phrases of the interviewed specialists' are cited in between of segments of the designed business model. By citing the specialists' opinions the validity of our business model is enhanced as well as a more elaborated and spherical approach for the SDN domain and business model is made. More specifically, in the fifth chapter where the design of the business model is made, the case study of Capgemini is made through the internally contacted interviews and recommendations, novel ideas, strategies to be followed derive from the interviews too.

Regarding the *verification* of the interviews' data, the method of *participants' validation* is practiced. This means that after the interviews are conducted and afterwards transcribed, they are send together with their interpretations to the according interviewed person in order for him to validate of whether or not the outcome is accurate and as indented to be during the interview (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008). Additionally, in order to ensure the privacy of all participants – interviewees all the interviews are anonymized. The anonymity is applied mainly for two reasons: firstly, for the protection of interests of companies and their employees and secondly to allow the interviewees to freely express their opinions.

#	Person Interviewed	Code	Actor	Scope of interview
1	Senior Network Architect	II1	Capgemini IO	Service, Technology and Organization Domain – Quick Scan
2	Senior Network Engineer	II2	Capgemini IO	Service and Technology Domain – Quick Scan
3	Senior Delivery Networks Manager	II3	Capgemini IO	Financial Domain – Quick Scan
4	Senior Managing Consultant	II4	Capgemini IO	Financial Domain – Quick Scan
5	Merged interview with two Senior Solution Architects	II5	Capgemini IO	CSFs, CDIs
6	Senior Infrastructure Innovation Consultant	II6	Capgemini IO	CSFs, CDIs
7	Senior Infrastructure Architect	II7	Capgemini IO	Robustness Check
8	Senior ICT Architect	EI1	Customer Company 1	Service Domain – Quick Scan
9	Chief Security Officer of a Large Enterprise	EI2	Customer Company 2	Service Domain – Quick Scan
10	Merged interview with Country Manager Networking Solutions and a Senior Account Manager	EI3	Network Infrastructure Vendor 1	Technology Domain – Quick Scan
11	Senior Account Manager	EI4	Network Infrastructure Vendor 2	Technology Domain – Quick Scan
12	Senior Account Manager	EI5	Network Infrastructure Vendor 3	Technology Domain – Quick Scan

Figure 16 – Detailed list of interviewees

4.4 Progress of master thesis' research status

Recapitulating, this master thesis is a single case study and is making use of qualitative exploratory methods. It is intended to acquire tacit knowledge through semi-structured interviews with experts and complementary desk research.

At this point the fourth chapter is completed and together with it the first part of this master thesis. The second part of the master thesis consists of the design of the business model and starts with the following fifth chapter. In the next figure is depicted the progress of the master thesis' research together with the planned to be made research through the rest of the chapters.

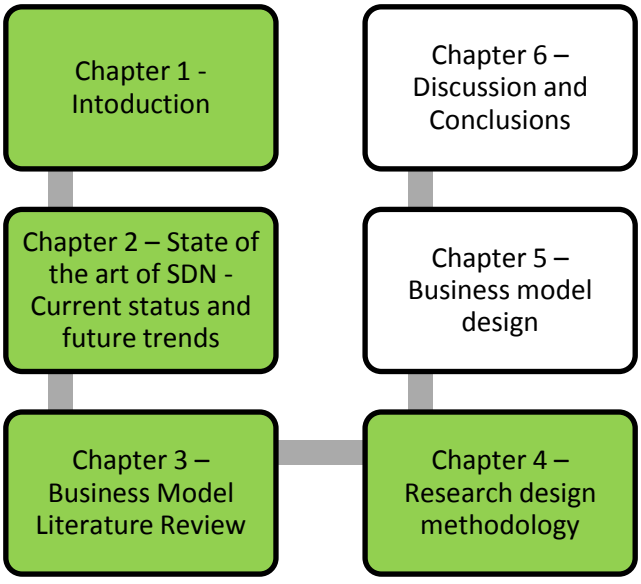

Figure 17 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

5 Chapter 5. Business Model Design

5.1 Introduction

With chapter five the second part of this master thesis is introduced in order to give an answer to the third research question of the master thesis. The design of the business model is going to be implemented in this chapter. And as it was discussed in the fourth chapter as well, the framework that will be used for the design of the business model is the STOF framework of (Bouwman, De Vos, & Haaker, 2010). All the consecutive steps for designing the business model are included in this chapter. The final designed business model, together with the quick scanned version of the current business model of the IT service provider are presented in this chapter too. Additionally, major changes based on the CSFs and CDIs as well as the semi-structured interviews with specialists will be referred and analyzed in this chapter too.

5.2 Quick scan of IT service provider's current business model

As referred in chapter four, a semi-structured interview regarding the current business model of Capgemini's Infrastructure Outsourcing department (IO) should be executed in order to give a base for the new business model that is indented to be designed. This interview took place with a highly ranked architect of Capgemini's Infrastructure Outsourcing department, cited as Internal Interviewee 1 or II1 from now on. The interview's protocol can be found in the Appendix. Based on the content of the interview and the official website of Capgemini IO (Capgemini, 2014), STOF's four domains were filled in as follows:

5.2.1 Service Domain

IO is having four main services in its portfolio. Namely these services are Remote Infrastructure Management (RIM), Workplace Services, Data Center Services, and Cloud Computing – Infrastructure as a Service (IaaS). Capgemini at the moment is focusing its services only on large enterprises with budgets for IT expenses that are higher than Z million euro *(the number is masked for confidentiality reasons).* More specifically regarding the four services motioned, RIM is providing to customers administration of company networks either remotely from the site of the company or by the "lift and shift" technique, when the network infrastructure of a company is entirely moved in the premises of Capgemini so to be administered locally. Workplace Services is related with the provision of virtual workstations to employees of customers. This is achieved with virtualization of infrastructure and innovation in the classic end user hardware. Data Center Services, optimize clients' data centers to save money and add value to their business. This service's focus is also on companies that are not willing to completely update their infrastructure; but on the other hand are in the need to improve their infrastructure's utilization and effectiveness. The Infrastructure as a Service, is the provision of remote infrastructure utilization for the needs of the customers. All of the required infrastructure is located in the three datacenters of Capgemini Netherlands. Of course added value to IO's services is the knowledge that is provided to the customers from the employees of Capgemini. Some customers of IO internationally, are the Administration of the Port of Lisbon in Portugal, Kadaster in Netherlands, Her Majesty's Revenue & Customs (HRMC) in UK (Capgemini, 2014), (Kadaster, 2013).

5.2.2 Technology Domain

In the majority of the cases Capgemini IO has the needed infrastructure to serve its customers' hardware and software requirements. So extra infrastructure is only bought if required to support a customer's extra needs. In cases that high investments are necessary, the approval from the headquarters of the company in France is a prerequisite (II1).

Capgemini IO is trying to be using open source software solutions for its services. Open source software allows customization for the needs of the customer plus is free of licensing costs (II1). Capgemini is developing its own open source solutions but uses off the shelf software too (II1). For example, one of the latest additions to Capgemini's Open Source Software portfolio is "Clair", a Software as a Service (SaaS) professional communication and connections' management solution (Capgemini, 2014).

Important to be mentioned as well is that the infrastructure and software that is used by IO is provided by companies that are allied with Capgemini also labeled as golden partners. Allied companies are providing their own know-how to the company as well when needed and more importantly are supplying hardware and software on lower prices (II1).

On the following figure is depicted on a high level the architecture of Capgemini's datacenters. There can be seen all of the basic users and customers of Capgemini IO. Of course the figure is related with the IAASs. The structure of the datacenter is based on a fat tree architecture (Leiserson, 1985). Access to the network both physically and virtually only have the authorized personnel, users and customers depending always on the occasion and privileges that each individual has (II1).

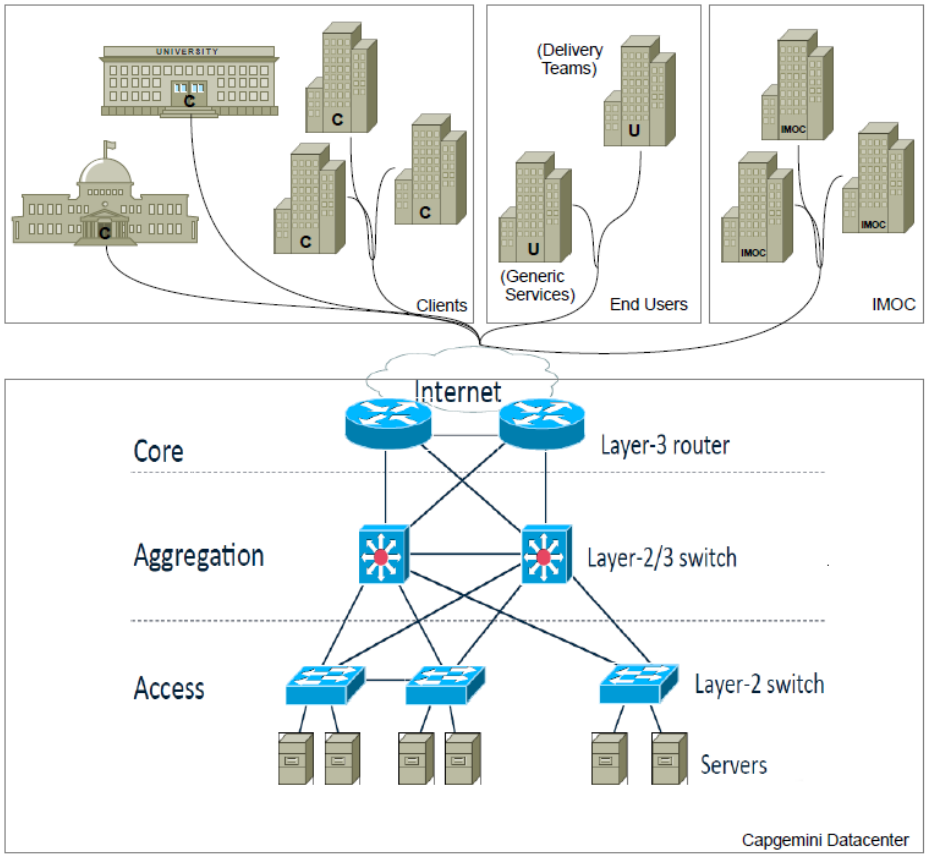

Figure 18- Architecture of Capgemini's current datacenters

5.2.3 Organization Domain

As referred in the technology domain, the purchasing of infrastructure is mainly made through golden partners - allies of Capgemini. So these companies are involved in the value network of the company when purchasing of new equipment and software is made for the support of customers' further needs. But the main stakeholders are the shareholders of Capgemini (II1). Since Capgemini is a publicly traded company and the shareholders are having voting rights they can formulate the strategic decisions of the company. Moreover the managing board of the company is responsible to approve new purchases of equipment for new or potential customers, something that can be problematic sometimes for IO's teams (II1). The decision making process usually takes time, which significantly compromises the flexibility of IO.

5.2.4 Finance Domain

The revenues of the company in cases of "lift and shift" are made by charging customers by the m^2 or m^3 occupied in the premises of Capgemini's datacenters, by the amount of the storage and CPUs used, by the cooling equipment used, the number of network ports utilized and the power needed to operate their infrastructure. The customer has to pay for the space its infrastructure takes in the datacenters of Capgemini and the operational expenses of them. In cases that the customer wants to keep its infrastructure in its own premises, the expenses are mostly based on the human resources of Capgemini that are occupied for the specific project. In any case the expenses are calculated based on operational level agreements (OLAs) between the customer and Capgemini IO. As mentioned in the Organization domain, Capgemini is having alliances with hardware and software vendors in order to be able to buy software and hardware at low prices as well as have the support of these industrial partners when needed. Last but not least the utilization of open source software is lowering the total cost of the services, since it is possible to be used for free because it does not require licensing. (II1)

5.3 SDN business model

5.3.1 Quick Scan

The quick scanned version of the SND business model is based on the semi-structured interviews and desk research of SDN related papers and Capgemini's reports. The interviews are conducted internally at Capgemini Infrastructure Outsourcing Netherlands and externally with multiple interested in the SDN business model stakeholders. Such stakeholders are network infrastructure vendors, customers and end users. Moreover, the outcomes of the literature study for the SDN domain that we made in chapter 2 as well as the study of the current business model of Capgemini IO as noted down on the above section are taken into account for the generation of our business model. All these sources are combined together as indicated by the theory of triangulation for the reason we discussed in chapter 4.

Service domain

Value Proposition: the value proposition factor together with the market segment factor are the starting points for the design of SDN business model's quick scanned version. The value proposition of SDN service is mirrored in the technical capabilities of SDN technology and its use cases as we described them in Chapter 2, as well as on its beneficial business extensions for all of its stakeholders. More analytically, the value proposition of the designed service is a bundle of SDN functions that benefit – create value in multiple aspects for the customers and end users. The essence of the value proposition of the designed service is summed up in the next two lines:

SDN is an architectural approach that optimizes and simplifies network operations, speed ups service delivery and lowers operational costs by employing a point of logically centralized network control.

The speeding up of the service delivery might even save whole days from the design cycle, depending always on the changes that have to take place in the network. In the contrary, existing large scale conventional distributed networks require days for their reconfiguration. SND technology allow the reconfiguration to take place in some hours. Additionally, the human errors are minimized as well, since there is no need for updating of the network infrastructure's cable patching anymore. The added value of the service is expanding at savings of hardware costs. Vendor agnostic SDN switches - white boxes, can be used for the processing of network's traffic. So no commission fees are paid for proprietary rights to companies that hold them. Plus, all of the switches can be administered from the centralized controller, which is running on open source software as well. The ability to modify the quality of service (QoS) of the network through the awareness of traffic is possible as well. Moreover, there is enablement of testing new routing protocols in the network without compromising its efficiency. And real time updating of the network's policies is possible as well. Last but not least, enhanced security features are provided from SDN and reduction of the electric energy consumption is possible too. SDN can automate the administration of a large scale network and provide all of the above services as a bundle. All these features are mentions in chapter 2 and the bundling of the services is explained in more detail through the specific section of the service domain later on too.

Delivered Value: On top of the value proposition of the SDN bundled services is added the help line support of the customers through the Infrastructure Management Operations Center (IMOC). As cited in the official website of Capgemini (Capgemini, 2014), IMOC is a control room responsible to bring in contact customers, delivery teams and generic services personnel in case of an incident. In any case IMOC is monitoring the health and status of clients' infrastructure around–the–clock and has a first-line support in 35 languages. If the first line support is not adequate to resolve the issue, then a second line support provides base-level technical support to the client. And if the second line support is not adequate as well, then the IO teams of Netherlands are informed. In most of the cases, issues are treated automatically and instantly from IMOC, without any inconvenience caused to the client (II1).

Previous experience: SDN is a totally new service, so the end users and customers can forecast the performance and outcomes of the service based on white papers they have read, the marketing that is made for the technology by evangelists of SDN and network infrastructure vendors, as well as by the implementations that big companies have invested into as was mentioned in chapter two (Bouwman, De Vos, & Haaker, 2010). The currently "outdated" but well trusted technologies used in datacenters are operating based on distributed routers and switches that are only having knowledge of their nearest neighbors' functional state. On the other hand, SDN due to its ability for global visibility of the network's state can be of a great benefit for a datacenter and through that can bring high expectations to customers and end users.

Anyhow, SDN is not fully compatible - and in some cases not compatible at all - with the current computer network infrastructure (see chapter two). New switches are needed to support the technology as well as SDN controllers to orchestrate them. So for the case of Capgemini as the end user, it is difficult to have a preview and a better practical understanding of the technology before implementing it in the datacenters of the company. As for the perspective of the service's customers,

through two individual interviews with two of Capgemini's big customers we got the answer that they haven't till now any prior experience but still they are looking forward for the first implementations. More specifically the two interviewees mentioned the following when they were questioned about alternative services and previous experience: "*We have nothing in it. Two years ago the sourcing (from Capgemini) started and then we saw the innovation of SDN. We expect from Capgemini the day that will bring us these new services.* (EI1)*"*. As for the second interviewee he was direct with his answer as well and mentioned: "*No we don't use any alternative (to SDN) services. And I don't know any others either* (EI2)*"*.

Expected value: From the customer's perspective, the expected value from the SDN services is primarily the lowering of expenses and the faster provision of required new services. Moreover the customers are concerned for the reliability of the network's function and they want to keep having constant uptime of their network's functionality, as it is with the current provisioning situation as well. More specifically customers mentioned that: *"It is more about flexibility. We want to work agile so we have the method SCRUM, we have sprints of two weeks. We need systems or use cases to test and ways to build virtual environments in a faster way for our projects. Provision of networking was always late. So I believe that in the long term SDN will save us money because of the shorter design cycles.* (EI1)". The opinion of another customer aligns as well with the up the first statement: "*We expect shorter delivery times and cheaper provisioning perhaps. But especially shorter delivery times. As long as reliability is never less that current is. We cannot live with less (reliability) than we have now.* (EI2)" The perspective of end users (generic services and delivery teams) is in the same concept as well (II1 & II2). Capgemini IO as an IT service provider, expects to be able to provide services much faster and less costly. These expectations are mostly created by the automation that SDN can provide to the network as well as the decrease in the number of employees that were previously required for the same tasks that SDN can now automatically implement.

Perceived Value: is the difference between delivered value and expected value. It is difficult to make a statement for this factor since the technology is not implemented yet and its novelty generates uncertainty too. Most probable is the scenario in which the high expectations created from marketing promotions create a really high expected value by the customers which will be hard to compensate with the actual delivered value. At least this could be a problem in the initial period of the service's provision, mostly because of learning curve effects of the service provider. One of the customers commented on this issue as follows: "*It is usual that the delivery times are not met and the agreements are not kept. But this has to do with the service level agreements (SLAs). For the expected value, partially it depends on how the service was sold to us. And if we are promised golden hills and got delivered only silver bumps then we will be dissatisfied of course. But we will not go to an unknown area; it should be a proven technology.* (EI2)*".* So the way that Capgemini will sell the service to its customers should give a clear idea of SDN's capabilities and not create misperceptions to the customer, something that leads to low satisfaction of the customer. Additionally, this statement proves as well the concern of the customers for non-proven yet technologies. Despite the advantages of SDN, the customer is skeptical into adopting the service unless it is totally sure that it will work flawlessly. So, a second conclusion, part of the customers' expectations is the reliable provisioning of the service.

Market Segment: refers to the customers' domain that our service will focus on. The market segment in which the Dutch branch of Capgemini IO is focusing on is the large enterprises of

Netherlands. This is mentioned in the preparatory study of the existing business model of the company in the beginning of this chapter as well. And since we are designing a model that we of course intent it to be good, based on (Casadesus-Masanell & Ricart, 2011) we are going to align our business model with the strategy of the company. Moreover, based on statistical data of the European Union, in 2013 there were 1,514 large enterprises in Netherlands. Which represent merely the 0.2% of all the enterprises of Netherlands. But these enterprises are capable of occupying the 33.7% of the country's manpower that is equal to 1,804,649 people. Furthermore, large enterprises established in Netherlands are adding a value of 107 billion euro that is the 36.2% of the total value added from the sum of enterprises in Netherlands (SBA - EU, 2013). So, since large enterprises generate almost one third of the added value from all enterprises in Netherlands and occupy the one third of the manpower of the country as well, it may be assumed that there are many opportunities for an IT service provider in this market segment.

Customer's Tariff: is the amount of money that the customer has to pay in order to have the service delivered to him. For the case of SDN, the customer is not going to have to pay more than the amount of money as used to pay when was served through the conventional distributed infrastructure. Customers have stated that they will not accept to pay more in any case: *"I don't think that I would pay more; unless it would be very explicit value offer for us. IT is a commodity these days and you are not willing to pay extra for a new luxurious commodity. IT is not special these days. You expect it to work always and you don't want to pay more for it. (EI2)". The second interviews customer stated that: "No, I want it for the same price. In IT you get more value for the same money. And you are going to use it if it's cheaper.* (EI1)*".*

Since automation is enabled in the datacenters by SDN, many of Capgemini IO's employees are not going to be needed anymore for functions that till now were manual are going to be automated. So these personnel can be transferred to work on other projects of the company. This fact means that the operational expenses (OpEx) of IO decreases and there is more margin for revenue in Capgemini IO. If the automation fact is combined with the fact of faster designed cycles, then it is made more evident that the OpEx can decrease even more and the margins for revenue are expanded. More about the financial aspect of the service are discussed at the Financial domain of our business model.

Customers and **End Users:** As *customers* are defined the ones that are paying for the service and at some respect utilize it (Bouwman, De Vos, & Haaker, 2010). The following figure depicts of how the structure of Capgemini IO is and how its customers are served. SDN is delivered as a service to the customers of IO as far as they are paying for it. The department of generic services is providing all the needed services to the delivery teams that in their turn are each one dedicated to a specific customer. If a customer has a specific requirement that is not covered by generic services, then the delivery teams have to satisfy it (II1).

As *end users* are defined the ones that are fully utilizing the service but they don't necessarily have to pay for it (Bouwman, De Vos, & Haaker, 2010). For the present case study, end users are the internal teams of Capgemini IO, namely: generic services and delivery teams. Capgemini IO is receiving money from the customers in order to provide them SDN services and simultaneously is utilizing the SDN technology in order to provide it as a service to the customers. So the internal teams of IO are fully taking advantage of SDN technology's capabilities and they make sure to deliver them as a service to their clients (II1).

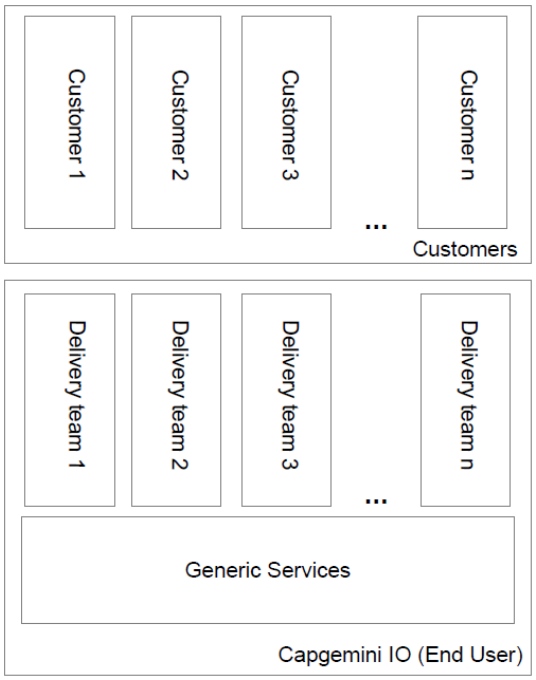

Figure 19 - Organizational Structure of Capgemini IO

Effort: is the easiness with which the end user and customer make use of the service. Since the customer gets the network solution as a service by the IT service provider, not much will change for its case. On the other hand, the IT service provider will have to train its engineers for the new technology. Learning curve effects will take place and funds will have to be spend on the SDN related training of the engineers. Due to the learning curve effects, the full capabilities of SDN technology will be exploited in depth of time as well. By the time the employees of IO will get more and more aware of the technology's capabilities and will exploit them. One of the customers mentioned the following that are aligning with our design as well: "*It is a service for us as a customer, I don't think that we have to make any extra effort. It is a black box provided from a provider like Capgemini. If you do it yourself then you have to train people and have to change the way of thinking as well, this will cost the employees some time to get it and understand it. So you have to train them and they have a learning curve. It's the same with all the new technologies in the beginning, it costs you effort and at some point its everyday work.* (EI1)". The same perspective is given from an employee of Cagemini IO: *"People are already thinking about SDN. But before we go SDN live, we will have a lot of people going on courses, so they can get certified professionally or at least get familiar with the new technology. Later on, after the employees are trained; we will run some test labs to see how it will go, then we will do test migration to see how things work and if they go as expected then we will go live for the customers* (II2)*".* As it derives from this statement, there is need for a lot of effort from the employees of the service provider. Anyhow our model focuses on the market phase, when the SDN infrastructure will be up and running to serve the customers, so the road-mapping to this state is out of our research's scope.

Bundling: SDN technology is multisided and as it was analyzed in depth in the second chapter of the thesis as well there are many use cases of the technology. Consequently many different but still interrelated services can derive from SDN enabled datacenters. So from the SDN enabled datacenter of Capgemini Netherlands too. Important to be mentioned as well is that bundling of services is increasing the proposed value of the service itself. These services are grouped in categories and are

presented in the next table. For more information regarding the services the second thesis chapter can be reviewed as well.

Green ICT	Centralized control of network	Dynamic Update of forwarding rules	Software Based Traffic Analysis
Powering down of unutilized infrastructure; savings from 25% to 62% on energy expenses	Automation of the network that brings speed, flexibility, global visibility and predictability	Link failure recovery	DDoS detection enabled from neural algorithms and data mining techniques exploitation
	Enabled easier IT auditing	Auto bandwidth allocation	Source address validation from the SDN controller
	Real time network policies update	Load balancing	

Table 8 - SDN Service Bundling (see chapter two)

Technology domain

The technology domain is really important for the design of our SND business model and it is direct related with the abovementioned indented and delivered values that we discussed in the service domain. The service we are designing is clearly driven from the SDN technology and in the following paragraphs we will analyze how this technology is exploited for the needs of our model. SDN will enable the proposition of new services and subsequently new operational level agreements (OLAs) and service level agreements (SLAs) from which the end users and customers will be able to choose from to utilize. Of course some of the existing OLAs/SLAs will be automatically substituted from the novel SDN's OLAs/SLAs and will be by default provisioned to the client, instead of the old ones. Of course the enabling of agility and cost saving by SDN will help Capgemini IO enhance its strategy of providing customized services to its clients as well.

Technical Architecture: In the following figure can be seen on a high level the technical architecture of our service. On the lower wide box is depicted the SDN enabled datacenter of Capgemini. On the upper left box are included the large enterprise customers of Capgemini IO, and on the upper right boxes are the end users and IMOC of SDN service.

The datacenter's architecture is designed in alignment with the leaf-spine data center network architecture. The leaf-spine architecture in comparison with the classic hierarchical tree architecture, which is implemented in typical current datacenters, enables the Ethernet fabric concept. By this term we mean the interconnection of all the entities of the network with each other as well as the common knowledge of their status (Techtarget, 2013). Moreover, Ethernet fabrics "*provide higher levels of performance, efficiency, availability, and operational simplicity to meet the business needs of virtualized data centers*" (Brocade, 2014). From our conducted interviews one of Capgemini's network engineers supported the same approach as well: *"The SDN architecture will transform the networks from the classic tree topologies to leaf-spine topologies. So everything will be messed and able to be interconnected.* (II2)*"* Additionally, the end users, customers and IMOC, are connecting to the datacenter through the World Wide Web enabled from a secure, high bandwidth connection.

Infrastructure Equipment: For the delivery of the service it is necessary the integration of SDN compatible controllers and switches in the datacenters of the service provider, and Capgemini in our case. Two SDN controllers are essential for our implementation, one as the primary controller and one for backup. Additionally, multiple SDN compatible switches are needed to execute the commands of the controller. The switches are white boxes, which means that they are lacking of control plane functionalities and are only responsible and capable for the data plane's operation. The whole SDN solution is founded on open software solutions provided from established network infrastructure vendors. Or better, only from a sole vendor in order to avoid interoperability issues. As it is probably noticed from the reader, the customization of the SDN datacenter is based on the outcomes of the first research question that gave an answer for the current and future state of SDN technology. So the SDN datacenter's design is conformed to these SDN trends. This gives competitive advantage to the company since it sets the foundations for novel and innovative applications. As already mentioned, crucial point is the interoperability of the existing infrastructure with the new to be bought and careful acquiring shall be made so to ensure a flexible and robust future proof solution. Very high - redundant bandwidth is utilized between all of the internal and external connections of the datacenter, so bottlenecks are avoided. And of course, the communication is made through secure connections hence the data assets of the IT service provider and of its customers are protected from cyber-attacks.

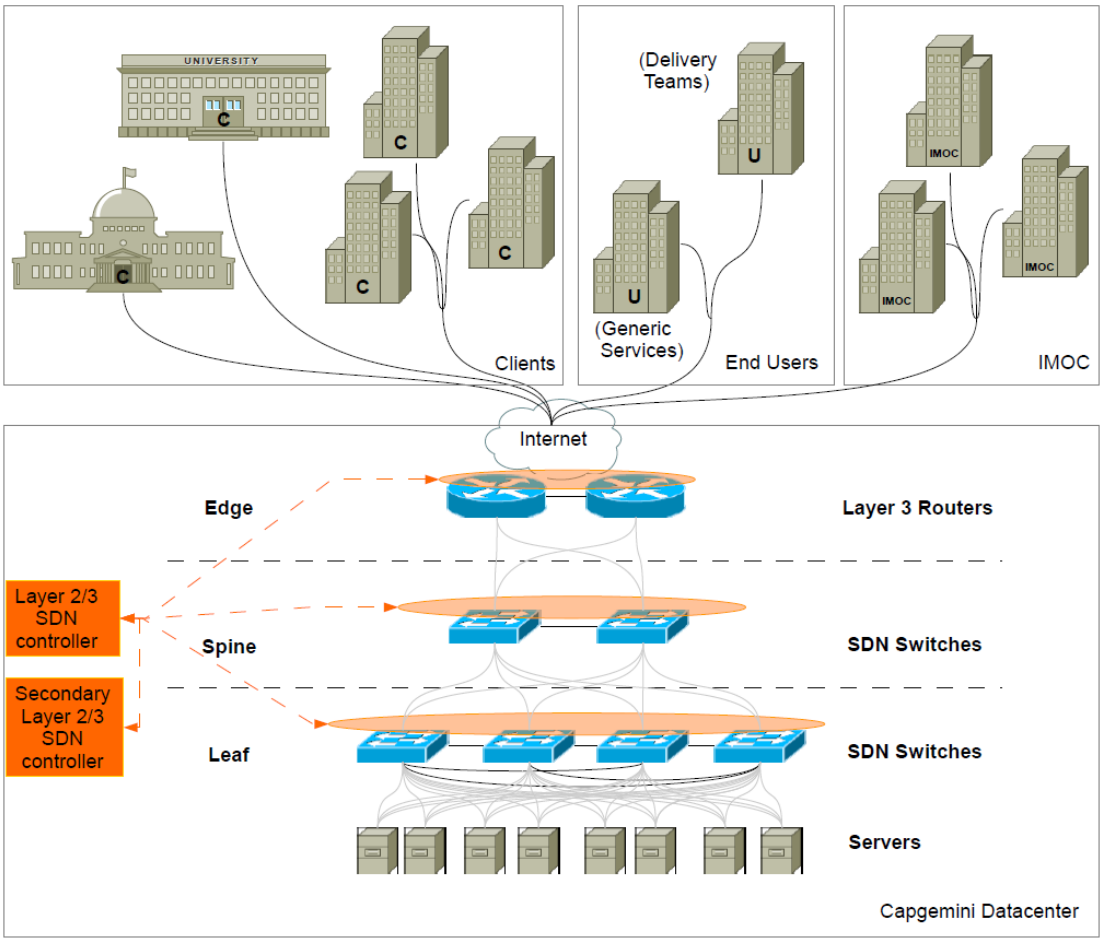

Figure 20 - Technical Architecture of SDN Service including infrastructure, end users, customers and operations center

Organization domain

Capgemini IO is the provider of the SDN service, but in any case, externally more companies are involved and internally many different departments of the company are engaged in order to realize the provisioning of the service. Each one of the involved stakeholders, internal and external ones, are having specific resources and capabilities that are necessary for the seamless provision of the service. On the one hand, each one of the involved stakeholders are providing their resources and capabilities but on the other hand they expect to have some value – tangible or not – generated for their own interests as well. In any case, a sustainable business model requires value generation for each one of its stakeholders (Bouwman, De Vos, & Haaker, 2010). Factors of the organization domain that are going to be analyzed for the scope of this thesis and the design of the SDN business model are the following ones:

Actors: are the structural partners of the network. We will refer to the stakeholders of our value network as actors from now on; the reason is that the chosen stakeholders are active and interact with each other (Grimble & Wellard, 1997). Plus, as already mentioned, for the chosen actors we are mainly analyzing and taking into consideration only the structural partners of the network, or else the tier 1 partners (Hawkins, 2002) in order to unnecessary increase the complexity of our business model. Additionally we are going to separate the actors of the network in internal and external ones as seen from the scope of Capgemini IO. Most of following actors and their roles have already been discussed in previous parts of the business model, anyhow a brief description will be made in this segment as well and it will mainly focus on their interaction in the value network.

- *Internal Actors:* are the actors that are organizational part of Capgemini and more specifically of Capgemini Infrastructure Outsourcing Services.

Generic services

The generic services team is the core actor of this business model. The employees that are occupied in generic services are the end users of the SDN service bundle. They are responsible to exploit all of the capabilities of the novel technology as well as provision it to the delivery teams that will on their turn provide it to the customers (II1).

Delivery teams

The delivery teams together with the generic services are the end users of the SDN technology. Additionally, they are the responsible ones to deliver the SDN service to the customers as well as cover all of the customers' special requirements. So in case that a customer demands a specific service that requires additional software or hardware acquisitions, the assigned to the customer delivery team will cover this need and by integrating it in the existing portfolio of SDN services (II1).

Infrastructure management operations center (IMOC)

IMOC team composes a control room responsible to bring in contact clients, delivery teams and generic services personnel in case of an incident. IMOC is constantly monitoring the status of clients' infrastructure and provides first-line support. If the first line support is not adequate to resolve the issue, then a second line support provides base-level technical support to the customer. And if the second line support is not adequate either, then the IO teams of Netherlands are informed by them (II1) & (Capgemini, 2014).

Executive board

The executive board is responsible for all the strategic decisions of Capgemini IO (II1). The role of the executive board that is related with the decision making processes of Capgemini IO, is active mainly when large investments are required to be made. In these cases the executive board has to approve these investments based on cost-benefit analyses and of whether or not they are aligning with the general strategy of the company.

Actors which are not mentioned in a separate section since their role is secondary for our business model, but are worth to be mentioned are the account managers of Capgemini IO. They are responsible for getting the requirements from the customers and negotiating the prices of the services with them as well.

- *External Actors:* are all of the actors that are not part of Capgemini IO's organization but still are necessary for the provision of the SDN service. These actors are necessary for the SDN service's provisioning due to specific resources that they have (Barney, 2001). Such resources are financial, technical and managerial resources (Miller & Shamsie, 1996).

Customers

The customers are the ones to keep the service alive. They are the source of income for Capgemini IO and all the rest actors are working for the satisfaction of the customers. So the customers are the consumers of the service. They are generating the need for cheaper and faster services provisioning and the IT provider is coming up with innovative services in order to achieve high satisfaction of the customers. The resource dependency that Capgemini IO has with its clients is really strong since the clients are the only source of financial income for the company (Pfeffer & Salancik, 1978).

Network infrastructure vendors

The network infrastructure vendors are having resources invaluable for an IT provider. They are capable of providing the necessary hardware and software for the implementation of the SDN solution that Capgemini wants to deploy. The dependency that the company is having to the network infrastructure vendors is high as well. Additionally, and as referred already, Capgemini is having alliances with multiple companies active in different domains of the IT industry. For our case, specific interest have the alliances with network infrastructure vendors. This kind of alliances are providing stability in the transactions between the companies as they are reducing the risks of uncertainties from purchasing expensive products and services as well as being able to rely on specific vendors for the provisioning of the required equipment (Sakaguch, Nicovich, & Dibrell, 2004).

Internet service provider

Internet service provider (ISP), is responsible for the provisioning of internet connectivity to Capgemini. And since Capgemini has ensured the internet provisioning, is providing internet connectivity to its customers as well through its own datacenters. Capgemini is having high dependency to the ISP, since all of the processes are taking place remotely from the datacenters. Only a small team of employees is located in the datacenters of Capgemini. The rest of the employees – end users and customers of Capgemini IO are connecting remotely through the internet to the datacenters in order to provide, administrate and utilize the SDN services.

Organizational arrangements: are made between customers and internal actors based on service level agreements (SLAs). (Kajko-Mattsson, Ahnlund, & Lundberg, 2004) mention about SLAs in their paper the following: *"there often exists a gap between customers' expectations for service and maintainers' ability to supply service. Hence, some form of an agreement is recommended to avoid conflicts. Such an agreement is called Service Level Agreement."* Additionally, one of the external interviewees mentioned that *"if we are promised golden hills and got delivered only silver bumps then we will be dissatisfied of course"* (EI2). So the SLAs of the SDN service should be well defined so to avoid any misconception and incorrect expectations from the side of the client as well as legally protect Capgemini IO.

As for the arrangements between internal actors, they are managed based on operational level agreements (OLAs). (Kajko-Mattsson, Ahnlund, & Lundberg, 2004) mention for the OLAs the following: *"Some kind of an agreement must be defined between the collaborating organizations as well. Usually, they are distinguished from those defined towards the customers, and called Operational Level Agreements"*. In our model these agreements are taken between the generic services teams and the delivery teams, so to make sure that the requested services are delivered as agreed between the internal departments of the company. As it will be discussed in the financial domain of our model, the calculation of expenses of the generic services to the delivery teams is made by utilizing OLAs.

Value network: Based on the abovementioned elements of the organization domain of our SDN business model, the value network of the service is drawn as seen in the following figure. In the network's visualization are noted the flows of tangible and intangible assets between the actors internally and externally of the Capgemini IO as they are discussed through the chapter as well.

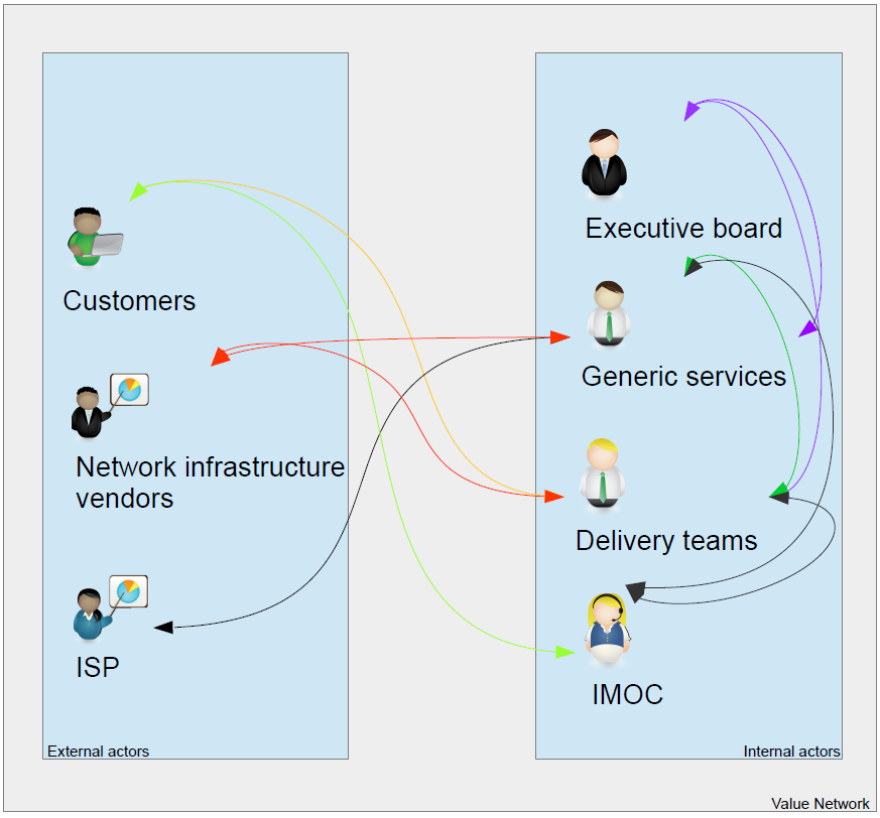

Figure 21 - Value network of SDN business model

Interactions: this section is related with the interactions of the structural partners of the service's value network. It is additional to the upper value network visualization and completes the organization domain's design. So in the next table there is succinctly described the interaction that each actor is having with the others. The table has listed in its rows and columns all of the actors and at the intersection of the cells the interaction of the specific actors is noted for each individual case.

From / To	Generic Services	Delivery Teams	IMOC	Executive Board	Customers	Network Infrastructure Vendors	Internet Service Providers
Generic Services	-	Provisioning of SDN services and charging for them based on OLAs	Technical support	Request for purchasing of financially highly valued equipment	-	Request for SDN network infrastructure	Request for internet services
Delivery Teams	Requests for SDN services	-	-	Request for purchasing of financially highly valued equipment	Delivery of customized SDN services	Request for SDN network infrastructure	-
IMOC	Technical support	Technical support	-		Technical support	-	-
Executive Board	Evaluation of proposals and admission/ rejection of them	Evaluation of proposals and admission/ rejection of them	-	-	Creation of strategic alliances	Creation of strategic alliances	Creation of strategic alliances
Customers	-	Requests for SDN services	Requests for technical support	-	-	-	-
Network Infrastructure Vendors	Provision of SDN network infrastructure	Provision of SDN network infrastructure	-	Creation of strategic alliances	-	-	-
Internet Service Providers	Provision of internet services	Provision of internet services	Provision of internet services	Creation of strategic alliances	-	-	-

Table 9 – Interactions of first tier actors

Finance domain

SDN's value proposition enables reduction of costs and faster delivery time, which subsequently will lead to increase of revenues as well. In the financial domain we are analyzing how the SDN enabled service accomplishes to save money for Capgemini IO, the risks that are taken from the company with the adoption of SDN, and last but not least the sources of investments and costs. It has to be noted that qualitative estimations are made for the analyzed factors of the service and approximate numbers are provided. Plus, it is not in the scope of our research the precise pricing of the designed service.

Investment Sources: The IT service provider is the sole actor that is investing for the update of the datacenter's infrastructure, i.e. for the transition to SDN technology. This means that the IT provider shall take 100% of the risk and responsibility for the investment. The update of the conventional

datacenter to an SDN compatible one is made possible from the investment that will be programmed to be made through the annual budget of the IT provider, and in our case Capgemini IO. It is part of the strategic goals of IT providers to constantly update their infrastructure for maintaining the competitive advantage in the market. More specifically for the case of Capgemini, and as it was already mentioned, large investment decisions are forwarded to the executive board of the company. There each individual business case is analyzed in depth and the decision for the approval or not of every large investment is taken.

Although there is an alternative for the financing of the new SDN based service. One of the interviewed customers proposed that the costs can be shared between its company and Capgemini IO in order to achieve an implementation that will serve its needs in an optimum way: *"I am willing to pay to do it together. So if Capgemini sees an opportunity for me and I see also an opportunity, I will invest in it to do it as partners.* (EI1)*"*.

Cost Sources: The cost sources are going to be grouped into capital expenses (CapEx) and operational expenses (OpEx). CapEx usually includes the expenses of a company for acquiring or upgrading physical assets (Investopedia, 2014). Whereas, OpEx are related with the all the other expenses that are necessary for a company to perform its daily business operations (Investopedia, 2014).

One of the interviewed highly ranked managers that works for a large network infrastructure provider, stated that: *"Approximately, the cost for upgrading a large datacenter like Capgemini's to support SDN technology (controllers and switches) could be approximately half million euro"* (EI3). This cost only regard SDN controllers and switches that will allow the administrator of the network to centrally control it and it is part of the capital expenses (CapEx) of a company. Extra costs that can be summed up as operational expenses (OpEx) of a datacenter, regard the hardware's and software's depreciation, the external support costs deriving from third party companies that are providing assisting services to the IT provider. And last but not least, one more major operational expense is this of the human resources, i.e. the expenses for the salaries of the employees working for the operation, maintenance and management of the datacenter. Of course part of the operational expenses are the monthly electricity bills, which as mentioned already can be radically reduced with the SDN technology's implementation. Reduction of costs applies for the man hours as well. The automations that SDN brings are going to make the role of some of the personnel redundant. And these employees should have to be transferred to other posts or divisions, either get training to assist the SDN services.

For the case of Capgemini, half million euro is an investment that should be approved from the executive board. Moreover, Capgemini is estimating the expenses as the sum of some factors, which cannot be mentioned in the public version of the report for reasons of confidentiality. Of course the CapEx is taken in advance as well but the way that the services are priced is based on the OpEx. More specifically, Capgemini is pricing each service based on the sum of these factors and divides it with the number of the entities that can be served to customers. For example, if the service provisioning is a network switch, then the expenses of it are divided with the ports of the switch that be used from customers. Each of the entities are named under an operational level agreement and the delivery teams are charged with the sum of OLAs that are requesting. More details about the OLAs and the pricing of them are given in the following elements of the finance domain of our model.

Revenue Sources: Of course main resource of Capgemini IO is its customers. This has already been discussed in the organization domain, when the dependencies between the actors were defined. It has to be mentioned that Capgemini's generic services teams are not aiming to make revenues but are only trying each year to reduce the cost of the services (OLAs) by a percentage of X% each *(the percentage is masked for confidentiality reasons)*. The responsible actors inside Capgemini IO to generate revenue for the company are the delivery teams and the account managers that are serving the clients directly (II3).

Much more, intangible benefits are generated from the provisioning of the SDN services. Tacit knowledge is build up internally in the company as the employees are getting familiar with the innovative technology. Additionally, cost savings are made as well due to the fact that the datacenters of the company are automated. As a result less man hours are needed to be spent in the management of the network, less human errors are made so less debugging is necessary, and the design cycles are much shorter and faster so financial resources are saved from this perspective as well. *"From an architectural overview it becomes much easier to deploy new environments and networks. If you now have a customer, at the moment you need to deploy everything manually. But with SDN you just create a flow and it's done. So you could say that for new customers you get quicker deployments. So you can save about 50 hours from a customer project when building a new environment; that adds up.* (II2)*"*. Much more, this particular automation can reduce the costs always depending on where the operations of the company are based. *"If you do operation management from India and you replace it with automation solutions through SDN the costs will be reduced a bit. On the other hand if you do it from European countries like for example Germany and Netherlands and then you have lots of cost reductions and it can even be 80%.*(II2)*".* The case of Capgemini is more on the first part of the statement, since the operation management takes place mainly in India through remote access to the datacenters of Capgemini IO in Netherlands.

Of a great financial benefit are the agreements that are made with all of the allied companies too. These agreements offer cheaper equipment provision as well as support of Capgemini's internal teams in the implementation of their own projects. Much more, renewing of contracts, a procedure that is taken care from the delivery teams and their account managers, is making sure that the inflow of revenue is constant and that the relations with the customers are in good terms (II3).

Risk sources: There are multiple risks involved in the provisioning of the SDN service. After an internal interview with (II3) we were able to locate some of them and we are presenting them in the next lines. We only refer to risks that can have negative outcome for the company, so in this segment is out of our scope to mention risks with positive outcome (opportunities).

One of the main underlying risks the one that can be categorized as a financial risk and regards the total required investment from Capgemini in order to enable its datacenters with SDN. In the most probable case that we analyzed prior, Capgemini has to invest all of the capital by its own. So in case that the project doesn't flourish as planned, the company will have to face big financial loses and not only. Maybe these loses will expand to cost the company's trustworthiness and competitive advantage too (II3).

Much more SLA penalties can derive from uptime availability issues (II3). For example if Capgemini with the SDN technology is not delivering of what has agreed to its clients, then SLA penalties will have to be paid from Capgemini. Many of the SLA penalties might derive from learning curves, i.e.

the delivery teams will be still figuring out of how to make the most out of SDN and the agreed services will be under-delivered. Another probable case that SLAs might be violated is when technical inconsistencies of SDN are happening, as it is a new technology and some unpredicted malfunctions might arise which will potentially cause failures in the system. Most of the times, these penalties are paid from the company to the customers as a reduction of the charged SLAs' prices to the customer (II3).

Another risk is the unbalanced service portfolio. Many services are going to be substituted – "cannibalized" from the novel SDN services (II3). So the portfolio of offered services should be updated and this might bring an imbalance to the existing SLAs as well as the necessary personnel needed to deliver these services. Due to the automation that SDN will enable, many of the employees might not be necessary anymore for tasks they used to be in the past. On the other hand other employees might be still needed but would first have to be trained for the novel SDN technology's utilization.

One more risk that can shake the stability of our business model is mismatches between contracts that are made with clients and use licenses for needed software. For example, for a special function of SDN maybe Capgemini will purchase a use license from the application store of one of the infrastructure vendors. But the case might be that each time that the function is used for a different customer, a new license shall be purchased. So legal matters might arise because of misuse of this concept.

Last but not least, a great risk might be the rejection of adoption of the SDN service from the customers of Capgemini. As one of the customers stated in one of the conducted interviews: *"We would like Capgemini to provide this technology to but it needs to be a proven technology first. Because this is so essential. We cannot take risks in our environment for something that is not completely reliable. Unless we can offload this risk to Capgemini."*(EI2). So Capgemini should make sure that SDN is a reliable solution in order to minimize the risks that takes with this transition, as well as have back to back agreements with infrastructure vendors and the rest of the stakeholders in case that SDN is now delivering as has to.

Pricing: The pricing of the SDN service is deriving from the combination of all of the above analyzed factors. Additionally, for the case of Capgemini the pricing strategy is having a rule of thumb. So the rule of thumb for the delivery teams and the assigned to each project and client account managers is to charge their customers approximately an extra Y% (the percentage is masked for confidentiality reasons) on the top of each service's (OLA's) cost, depending always on each individual customer and contract (II3). Based on an internal interview with (II2), we are able to recognize which of the OLA's costs can be lowered due to automation features of SDN technology. We concluded that out of the total of 23 OLAs the 13 of them are possible to have their cost lowered. This is translated to a) alignment with the strategy of the annual decrease of the OLAs costs, b) higher revenue margins for Capgemini IO and c) lower prices for the customers of Capgemini. Based on the pricing factors of Capgemini the OLAs price is fixed and on the top of it an additional Y% is added as the final price of the service for the customer. And as it was already commented in previous paragraphs as well, the human resource expenses are lowered too. So it can be assumed that the margins for lower prices and higher revenues are probable.

5.3.2 Update of quick scan version through CSFs and CDIs

In this segment of our design the second and third steps of STOF framework are going to take place. As described in the fourth chapter of the thesis, these two steps are implemented based on internal semi-structured interviews with experts from the domain of ICT. The interviews take place internally in Capgemini and the chosen CSFs and CDIs that are chosen based on previous interviews and desk research are discussed in order to improve the till now designed business model. There are conducted two separate interviews for these two steps of our business model's design. The first focuses on the creation of customer value and is carried out with (II6). As for the second one, it takes place with (II5) and focuses on the creation of value for the network. The table that is given in chapter four to depict the CSFs together with their CDIs is given here as well, to visualize the process better.

CSFs / CDIs	clearly defined target group	compelling value proposition	acceptable quality of service	acceptable risks	acceptable division of roles	lowered service prices
	targeting of customers	bundle composition	security	acceptance of a non-proven technology	network complexity	automation of processes
		services integration	delivered value	technology robustness enhancement	actors selection	internal re-organization

Table 10 - CSFs and CDIs

Creation of value for the customer

Clearly defined target group

This is a very important factor for the success of our business model. The focus of the target group is made clear already from the quick scan step of the business model, where we propose that focused target group for our services are large enterprises located in Netherlands. This support of ours is coming after the alignment of our business model with the strategy of the company to serve companies with budgets of Z million euro for IT *(the number is masked for confidentiality reasons)*. Although, (II6) supports that *"companies with Z M$ for IT annually in Netherlands might only be two or three."*, *(the number is masked for confidentiality reasons)* so the proposition of interviewee (II6) based on the CDI of targeting of customers is to *"focus on the customers of central Europe or even the entire Europe in general and expand the focus of the company as global service provider"*. Furthermore, for the targeting of the customers shall be taken into account that IT is not their main business, so to focus better on the companies that can potentially need sourcing services from Capgemini, (II6) comments that *"almost none of our clients have IT as their main business."*.

So the new market segment that our SDN service will focus on is:

Large enterprises located in Europe with IT spending budget of Z million euro, which moreover are not having IT as their core business. *(the number is masked for confidentiality reasons)*

Compelling value proposition

The existing value proposition is focusing on the technical capabilities of SDN and of how it can bring the change compared to existing solutions. And is phrased as follows: "An architectural approach that optimizes and simplifies network operations, speed ups service delivery and lowers operational

costs by employing a point of logically centralized network control.". Interviewee (II6) commended as well that *"the described added value description is focusing a lot on the technical capabilities of the service, so it makes it appropriate for the end users but not for the customers that will look mostly for the business gain of it".* So the value proposition to promote the service to the customers of the service that are less interested in the technical capabilities of the technology and more interested in the business benefits would be the next one; as for the value proposition addressed to the end users, it will remain the same.

An innovative service that automates network processes and results in significantly accelerated provisioning and lowered operational costs.

Moreover, for the CDIs of redesigning the bundle proposition and the way that the services are integrated within the current portfolio of the company, they were evaluated as being already well designed. Especially for the integration of the novel services in the portfolio of Capgemini IO, (II6) supported that they will just replace the old ones due to their advantages. But the transition process from the old to the new services is out of the scope of this thesis and we will not focus on this issue.

Acceptable quality of service (QoS)

This CSF is deriving from the need of the users and customers of the service to have a well-functioning service and much more a service that is mirroring the capital that is invested in it for its development and purchasing as per each actor. The CDIs that are discussed are the assurance of security of the provisioned services and the quality of the delivered value itself. In this case the assurance of the delivered QoS is assured through *"monitoring of the services and composition of service reports that are discussed with the clients, this process is followed with all the services of Capgemini. And it always depends of what is agreed with the customer through the SLAs.* (II6)*"* So for our SDN services, we will add features of monitoring the provisioned services and check of whether the agreed SLAs are kept as should be. Additionally, regarding the assurance of security of the clients data, the SDN services will have to meet the security certifications of Capgemini; i.e. the service will be designed in a way to be "*able to be certified with the information security standard ISO27001 and Payment Card Industry Data Security Standard (PCI DSS) specifically for customers that are involved in the electronic transactions domain*. (II6)*"*.

The completion of updates of our business model as derived from the chosen three CSFs and their CDIs, concludes the second and third design steps for the improvement of our business model in the domain of value creation for the customer.

Creation of value for the network

In this section we will research of how our business model can be improved into *creating value for the network*, as it will derive from the following four selected CSFs and their respective CDIs. The research for the improvement of value creation for the network is based on an internal semi-structured interview with (II5).

Acceptable risks

In order for a business model to be viable, its risks shall be acceptable from all the involved actors and they have to be balanced from the added value that will offer when taken. Much more, the factor will be in a better balance with the viability of the business model when it will be aligned with its matching CDIs. To begin with the CDI of accepting non proven technologies, (II5) comments that:

"SDN is a new technology and the customers are afraid of it, they should not be but they are. And that is a risk for first generation sourcing, if you are afraid of something then probably you don't want it either. " and the redesign solution for the mitigation of this risk is *"either to lower the prices that the customers have to pay for the services, otherwise give guaranties that nothing will go wrong and even if it goes wrong we will pay the price for that as Capgemini. We accept penalties on the service delivery and we take the risk away from the customer* (II5)*".* Something else that can help is to *"explicitly mention about the partnerships we have as Capgemini with big software and hardware vendors. This always helps and makes us more reliable for the customer as well as for our own risks since we can mitigate them to the vendors.* (II5)*".* So the differentiation in our design would be on agreeing with the customers on SLAs that any inconsistency caused from the new technology will be paid back from Capgemini. And in its own turn, Capgemini will have to claim the loses back from the relevant responsible vendors.

For the CDI of technology robustness enhancement, (II5) comment that the best design update that can be applied is to *"start lean and with the basic functionalities of SDN in the beginning, and add the fancy bits by the time. Moreover, a good thought is to stick to the technical architecture that the vendors propose and not implement really innovative solutions. This will help into troubleshooting support and in general will be easier to mitigate the risks to the vendor if something goes wrong. - Always use the standards. -* (II5)*"*. So for our SDN implementation we have to make sure that we stick to the selected vendor's architecture design and that we comply with all of the required and proposed standards.

Acceptable division or roles

As with the case of the acceptable risks, the acceptable division of roles is necessary for the balancing of the business model and it is enabling it to be viable. So in order to achieve this the CSF of acceptable division of roles is taken into advance in our design. CDIs that are researched in this section are the selection of actors and the complexity of the network. Beginning with the selection of actors, (II5) mention that: "*You need someone to push the SDN technology to the customers. Inside Capgemini these actors are the employees of Sales and Portfolio Management team. And they should be in between of all the rest actors, coordinating the projects. These employees are the evangelists of new technologies for Capgemini. Moreover they are gathering the requirements of the clients and they are communicating them with the internal teams of Capgemini.*" So our value network shall be updated as is depicted in the following figure. We are having one more actor that is responsible for the diffusion of the new services and is getting the requirements of the clients in order to analyze them with the delivery teams and the executive board.

Much more, (II5) stated that: "*Some time ago we upgraded our datacenters to a new storage technology. That was a technology push and we didn't have to ask our customers about it. They just got better services.* (II5)". Thinking in the same concept, SDN adoption by Capgemini can be a technology push to the market and the customers of Capgemini as well (Martin, 1994). And the employees of Sales and Portfolio Management team will be assigned with the role of the evangelists to promote the benefits of SDN to the customers as it was practiced with the upgrading of the storage technology. This way Capgemini can be a fast follower of SDN technology and seize all the second-mover advantages from it as well as benefit from the lessons learned from the growing pains of the first-movers (Anthony, 2012).

The CDI of the network's complexity it is regarded from II5 as being low and there are no necessary changes that have to take place.

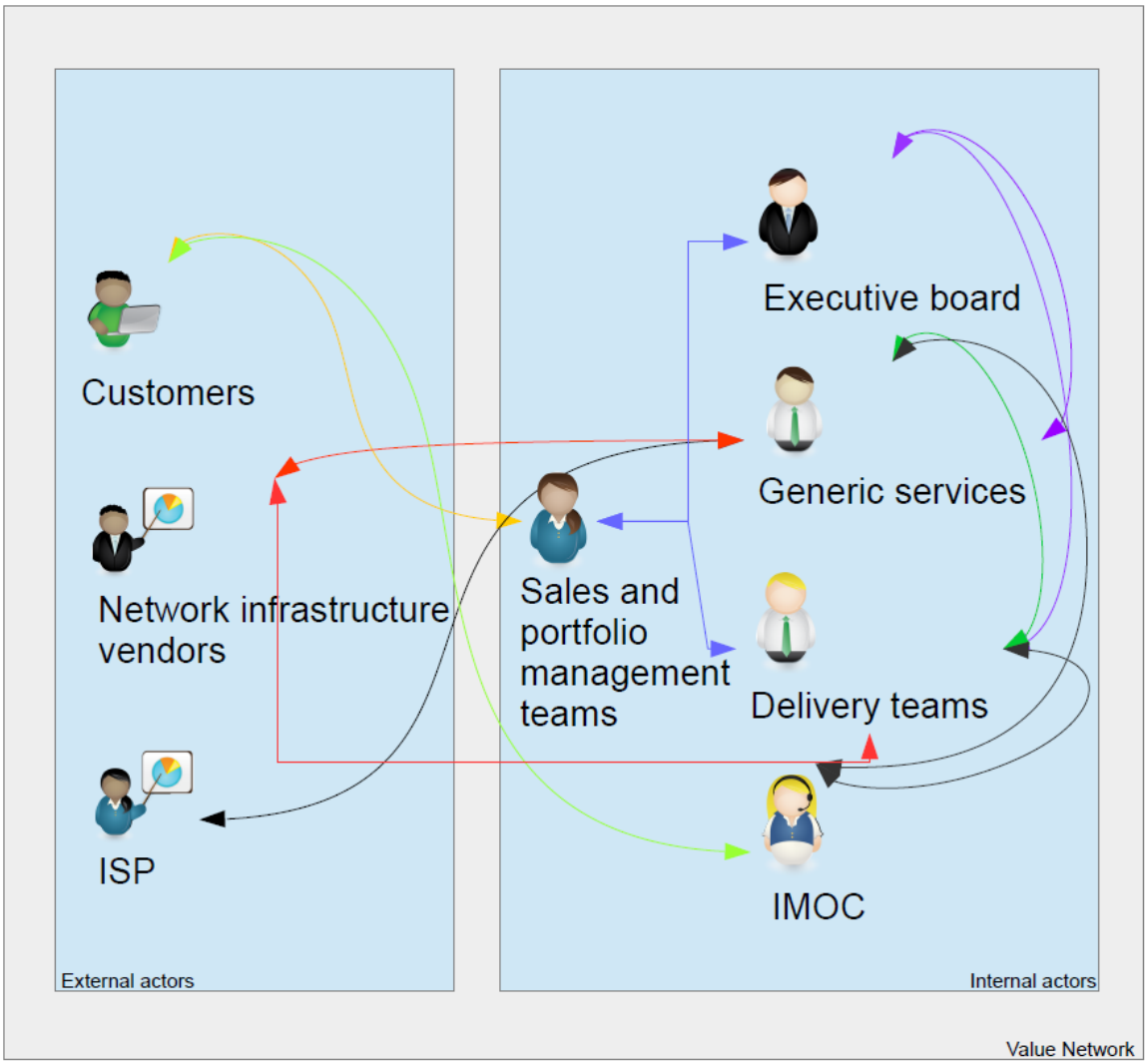

Figure 22 - Updated value network

Lowered or at least same level prices for the services

This CSF is deriving from the requirements of customers. During our interviews with customers, they explicitly mentioned that they are not willing to pay more for SDN services and much more they added that it would be good for them to pay less if possible, since IT is a commodity for them anyway (EI1)&(EI2). Based on the study we made for the quick scan version of our business model the reduction of the prices is possible. And the redesign based on the following CDIs may bring our business model closer to a viable design. (II5) mention that *"SDN is not only a mean to reduce prices, it is a revenue enabler as well. It can enable openings to new markets and provide competitive advantage to Capgemini. Customers that want to have private cloud, can have it through Capgemini's dedicated to them servers."*. Plus (II5) mention that *"Additionally, there is the choice to keep the prices on the same levels and invest the costs saved from SDN to improve the network itself. Of course the other choice is to give away the savings and lower the prices for the customers. And probably what is going to happen is something in between."* (II5).

Firstly the CDI of automation of processes is researched, so intention of SDN shall be the automation of as many as possible processes in order to accelerate the delivery time of services as well as decrease the costs for Capgemini and its customers too. As it is already said in a previous segment of our model, more than half of the offered OLAs can be updated through SDN, which means that the final cost of the services will be in any case equal or less expensive as is at the moment. So not many changes could be made in this part of our model to improve the pricing of the services.

The CDI of internal re-organization, has to do with the innovation of the business processes that could be enabled from SDN internally in the company. *"This is the highest achievement you can do in this company. It is really important for Capgemini to improve the way that business processes are made. Still this is something that can change really difficult inside the company due to the way that already things are done. Change is difficult to be made in business processes."* (II5) Although, *"if you start small and other people see the benefits then there is possibility for reorganization. When people will see something that they like they will do it for themselves as well* (II5)*"*. So what we can do for our case is create a small team that works in a more agile way and is taking advantage of SDN's benefits. This team can be the evangelist of the SDN technology internally in Capgemini, so as to make the rest of the employees aware of the novel technologies benefits. Of how this change will take place is out of the scope of our research.

5.3.3 Robustness Check

This is the fourth and last step of our business model's design. After the completion of this last step we will be able to support that we have designed a viable and feasible business model based on the novel technology of SDN. In this specific design step, we check of how our business model should react to changes of the external to the company business environment. Moreover, this last step can be regarded as a "crash test" of the business model, where likely to happen events are researched in correlation with our business model's design. Scope of these "crash tests" is to create a mitigation plan for each one of the cases. For the robustness check, an internal semi-structured interview with a senior architect of Capgemini (II7) takes place and we are analyzing the outcome in the next paragraphs.

Technology Cases

A new cheaper and better than SDN technology becomes available

*"In cases like this the customers might ask if we can provide it. And we, as Capgemini, will check if this is a profitable business case that offers enough benefits to the company. And if the customers are willing to pay for the transition to the new technology, where they recognize benefits for them as well, then we can provide it. On the other hand we can implement the new technology without even asking the client if we recognize large benefits from it"(*II7*).*

So there are two ways to move on when a better technology than SDN reaches the market. Firstly, if the customers are really willing to pay for the new technology-service, then Capgemini can provide it to them. And secondly, in case that the business benefits from the new technology are great for Capgemini itself, then the transition will be made without the involvement of the customers.

This means that innovation in our already designed business model might have to take place if a disruptive novel network technology is launched in the market soon. This way the viability of our business model can be still valid.

SDN fails to satisfy the expectations of end-users and customers

"If the expectations of the users and customers are not met then we have to redesign our business model's CSFs and CDIs."(II7).

So in case that the model fails to deliver the intended value that was promised to the customers and end users, we will have to reevaluate the critical success factors and critical design issues we chose for the design of our business model in first place and then redesign the necessary blocks.

The contracted network infrastructure vendor fails to deliver the required equipment

"This happens rarely, and in any case the procurement process shall be really clear. Financial penalties should be included in the contracts that will make the vendors compensate our company for the delay. Moreover there are alliance escalation models that are enabling our company to escalate the problem higher in the organizational hierarchy of the contracted vendor. Something that can accelerate the problem's solution. Additionally we have to inform our clients that we cannot deliver on time. But in any case we will not switch to another vendor, since this will take much more time and will change all of the planed infrastructure's planning. Still if this starts happening too often we will have to switch to a more reliable partner."(II7).

In this case the IT service provider has to have beforehand clear agreements with the vendor, including financial penalties in cases that there are delays of the agreed equipment. Much more, the escalation of the problem in the hierarchy of the vendor might help in the solution of the problem and for sure the customers have to be informed of the situation on time too.

Last but not least, it is preferable to stay with the same vendor despite its delay. Since in the end it might result that changing to another vendor will mean new technical architecture designs and new contracts. This can take much more time than the delay of the initial agreement.

Competitor Case

A competitor brings SDN to the market first

"There are multiple reactions that can be taken. One thing can be done is what percentage of the market is still open to be served. If the percentage is acceptable then we can continue with the implementation of the business model. Another choice might be to buy the service from the competitor and then sell it to our customers. (II7)*".*

So in a case that an IT service provider is not the first to launch a service in the market; based on the context of our interview there are two possible options that can keep the business model viable. First one is, that the IT provider gets to be a fast follower and implements the planed business model for the remaining market segment. And a second solution is a major innovation in the existing business model that will lead to buy the service from the competitor and then sell it to the customers.

Competitors sell the same services cheaper

"This really depends on the market segment you are focusing on. If the customers that you serve are still willing to pay something extra for the reliability that you are providing to them through your strong brand name and partnerships with big vendors, then your business model is viable."(II7).

In a case that competitors are selling similar services in lower prices, then an IT provider can promote its own special capabilities that are giving a competitive advantage to its company compared to the

rest of the competition. In case of Capgemini, these capabilities could be the strong internationally known brand name and the partnerships that the company has with other big international companies. These factors can enhance the reliability of the provided service and motivate the customer pay a little more for this extras.

Consumer Cases

Consumers reject the SDN due to malfunctions

"In case that something goes wrong for some unforeseen reasons, customers will hold Capgemini reliable for it. Then what we have to do is reevaluate the service. Of course this will cost money and it is not a position you want to be in. A backup plan for SDN is to make people again do all the work manually and stop using its automation features till the problems are solved. " (II7).

The mitigation plan in this case is the downgrading of the technology. For sure there will be revenue loses and dissatisfaction of the customers, but it's a one way solution till the technical problems are resolved and the agreed services are up and running again.

There is too high demand for SDN services and it cannot be satisfied

"This depends on how much the customer wills to pay. So one scenario is that we are queuing the request of this customer and inform him when we are ready to provide the service to more customers based on our own time schedule. This scenario will not have any extra costs for the customer. Another possible solution is to hurry up the provisioning of the service, but then the customer will of course has to pay extra."(II7).

This is a case that can be regarded more as an opportunity and not as a risk. It is relatively easy for a big IT provider to expand its infrastructure in order to serve more clients. The tradeoff for the customers will be between longer queuing time and higher capital investment, respectively for the IT service provider as well.

5.4 Answer for Research Question 3

The third research question is based on the research methodology that is used in the fourth chapter of the master thesis, as well as the literature review of the second and third chapter. In chapter two the state of the art of SDN was made clear in order to enhance the design of the SDN service as well as the technical architecture of it. In chapter three, STOF business model framework was chosen and in chapter four our business model's research design was made explicit together with all the limitations and requirements needed for a viable design.

Moreover, in the process of answering the third research question, STOF business model framework is parameterized in order to be aligned in the best possible way with SDN technology and the domain of computer networks. This parameterization is one more of the academic contributions of this master thesis. We believe that summarizing our SDN business model as an answer for the 3rd research question, can be useful and as it might help the reader understand better the context of the design model in a form a summary. Of course all the details of business model and all of its design steps can be found in the above sections too.

> **Research Question 3:** *Based on the selected business model framework, how does a viable business model that integrates SDN technology in an IT service provider's datacenter infrastructure, looks like?*

The answer to the research question will be given as derives from the four domains of our business model. So one by one the domains of service, technology, organization and finance will be recapitulated so to give a brief answer to the last research question of our research. Of course as mentioned above as well, the full business model is giving a much more complete answer to this research question.

Service domain

The value proposition for the end users of the SDN service, which are the personnel of generic services and delivery teams, is defined as follows: "SDN is an architectural approach that optimizes and simplifies network operations, speed ups service delivery and lowers operational costs by employing a point of logically centralized network control." And the value proposition for the customers of the SDN service is phrased as: "An innovative service that automates network processes and results in significantly accelerated provisioning and lowered operational costs." We have introduced two different value propositions for these two actors because each one of them emphasizes on what is important for each one. The first focuses more on the technology, while the second focuses more on the business benefits. Much more, the market segment that the IT service provider should focus on for this service are large enterprises located in Europe with IT spending budget of more than Z million euro *(the number is masked for confidentiality reasons)*, which moreover are not having IT as their core business.

Additionally, there is no previous experience on same services like the ones that are enabled from SDN. In any case, the customers are expecting fast service provisioning and flexibility. Although, the IT service provider has to make sure that the customers are not buying the service influenced from marketing effects. As SDN services are new and probably still vague for many of the customers, there might be created high expectations that cannot be met. Especially in the initial transitional period from the conventional services to the SDN ones, that the learning curve effects are more intense and the SDN technology cannot be exploited to its maximum capabilities. On the other hand, the customer is just the consumer of the service and does not have to worry for additionally required effort. Based on all of the above, service level agreements (SLAs) with the customers have to be clear so avoid miscommunications and unsatisfied customers.

Technology domain

For the technology domain the main outcome is that the architecture of the datacenter should be updated from the current tree architecture to the innovative leaf-spine architecture that enables the Ethernet fabric concept. For this transition new network infrastructure is needed. More specifically, at least two SDN controllers and multiple SDN switches, depending on the size of the datacenter, are necessary for the transition to the SDN technology. The switches are white boxes, which means that are dump devices only capable to manage the data plane. Much more, open source solutions are used for the algorithms and software that are running in the network in order to save on expense. Anyhow, the open source solutions are provided from established in the domain of computer networks vendors. This choice is made to ensure high level services and lowering of the investment risks. Last but not least, preference should be given to a sole vendor, so to ensure interoperability of

the networks infrastructure. As well as, the standard solutions of chosen should be applied in the datacenter of the IT service provider in order to make troubleshooting easier.

Organization domain

For the value network of our business model we selected the actors noted in the next table. We group the actors in internal and external ones, based on the organizational perspective of the IT service provider. All of the chosen actors are adding value to the network based on unique competencies they have. These competencies can be related with finance, technology and management.

Internal Actors	External Actors
Executive board	Customers
Generic services	Network infrastructure vendors
Delivery teams	ISP
IMOC	
Sales and portfolio management teams	

Table 11 - Value network actors

Through our model we discuss that the SDN technology is a novel concept that might create uncertainty and due to that reluctance to be adopted from the customers of an IT service provider. But as researched in our model, services based on new technologies can be pushed to the customers by companies when added value is seen in the new concepts for them and their targeted market segment as well.

Additionally, the adoption of SDN from an IT service provider can bring changes in its business processes. This happens due to the automation that SDN brings and many of the old services that were delivered manually now could be provisioned automatically by SDN's system much faster as well as less costly. Although, for a company as Capgemini changes in the business processes are hard to take place. Interviewees mentioned that a way to achieve changes in the business processes might be to create new teams that work in a new way so to inspire the rest of the employees to work in the same way and follow the new processes that will improve their efficiency. But business processes innovation is out of the scope of our research and we will not research this any further.

Finance domain

We have separated the cost recourses in operational expenses and capital expenses. Main capital expense is the one time investment that has to be made in order to upgrade the datacenters to the SDN technology. Main operational expenses are these for the salaries of the employees as well as the ones for the electricity expenses of the datacenter together with other fees that have to be paid periodically for the normal functioning of it. One more major operational expense source is this of the external services that are provided to the IT service provider from other companies and its difficult to be decreased. But SDN with its ability to automate processes can decrease the costs for the personnel that is needed to provision services to the clients. For example SDN can save up to 50 hours of work for the provision of a new service to a customer. Much more, as seen in previous segments of the thesis, the energy that is consumed from the datacenters can be reduced through intelligent SDN algorithms.

On the other hand, major revenue source is the cash flows from the customers that are paying for the provisioning of the services to them. Additionally, alliances with software and hardware vendors are saving expenses through major purchases and guarantee high levels of support to Capgemini.

Next we will briefly refer to the risks that the IT service provider has to take for the provision of SDN services as well as the strategies to mitigate them. One of the risks is the SLA penalties that might have to be paid to the customer in case that the SDN services are not delivering as agreed. Back to back agreements with network infrastructure vendors and software providers can be helpful in these situations. They can solve the problems and if the problem is caused from them, then they are the ones to cover the penalties. Much more, during the initial period of SDN services provisioning the IT provider shall provide only the basic SDN services and when the concept matures internally in the IT provider and its employees are close to master the technology, then the provision of more complex services can be initiated. Another risk is the probable rejection of SDN from the customers due to its novelty. A strategy to mitigate this risk is the reduction of the charging fees for the services as well as the promotion of the partnerships that the IT provider have. These can help by giving financial motivation to the customer as well as making sure that the solutions are under total control and guaranteed from multiple actors.

Last but not least, regarding the pricing of the SDN services, it can derive from a combination of factors that will be explained in the next lines. Capgemini has as a goal the reduction of OLAs' prices every year. And when the OLAs are delivered to the delivery teams, they are charged with an extra percentage so that the customers will pay the final SLAs' price and the company will make profits. As we mentioned above, SDN can reduce the expenses and our research showed that more than half of the network related OLAs can be lowered, so the SLAs' prices can be lowered too. Much more, as we discussed already, SDN is not only a source to reduce prices but it's a source to create revenue as well. SDN can allow customers have their flexible private cloud in the datacenters of Capgemini, something that will give completive advantage to the company and will generate revenues too. Plus the decreased OLAs can allow to invest more of the annual budget's money to the datacenters of the company so to improve even more the SDN services, while the customers will have to pay less for them. Target of the company should be the automation of as many possible processes through SDN.

5.5 Progress of the research

With the completion of chapter five, the design of our business model is finalized and we believe that as an outcome we have a viable and feasible SDN based business model. So the completion of chapter five gives answer to the third research question. In addition, the following chapter is dedicated to results, recommendations, reflections, limitations and future research topics.

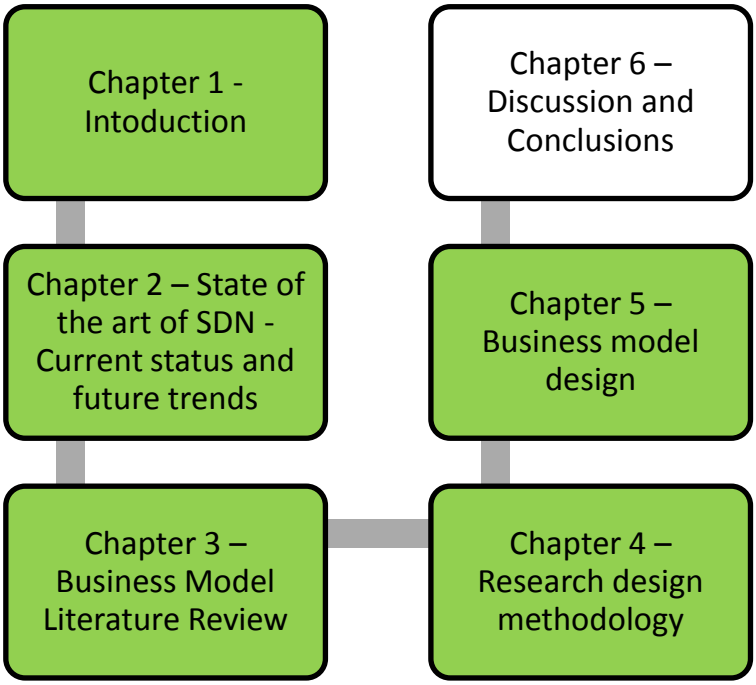

Figure 23 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

6 Chapter 6 – Discussion and Conclusions

This chapter is dedicated to give answer to the main research question of this master thesis, as well as give an insight to the practical and theoretical contributions of our research. Moreover, there are discussed the limitations of our research, reflections on it, practical recommendations for an IT service provider and last but not least are proposed future research topics.

6.1 Conclusions

6.1.1 Results

Our main research question as referred to the first chapter of the thesis is:

Which would it be a business model for integration of SDN services in an IT service provider's service portfolio?

First we will recapitulate the answers of the three sub research questions and then the final answer to the main research question will be given.

Research Question 1: *What is the state of the art of SDN?*

The first research question was answered in the second chapter of this master thesis. A detailed literature research of the current state of the technology as well as the future of it was necessary in order to give an answer to the research question. The information generated from the first research question was used later on to allow the design of our SDN technology based service. We divided the first research question in two parts. One related with the current state of SDN and the other related with the future trends of it. More specifically:

> **Sub-Research Question 1.1:** *How does the current market and technical state of SDN looks like?*

SDN is currently still in its early adoption phase and OpenFlow is the dominant enabling protocol. There are many different SDN controllers in the market and many are the nonproprietary projects that big established infrastructure vendors support. Standardization organizations and big established infrastructure vendors are promoting the technology with every mean and strategy. Last, use cases of SDN are focusing on: network management and availability, security assurance and innovative wireless implementations.

> **Sub-Research Question 1.2:** *Which are the future trends of SDN?*

Innovative startups in the domain of SDN are marketing cutting edge technology implementations aimed at pure switches, virtualizion of all OSI's layers, and utilization of open standards and open projects. Additionally, SDN is one of the top 10 disruptive technologies to have impact in the industry for at least the next three years, since SDN market will grow to $2.45 billion till 2018. Academic researchers are exploring the capabilities of SDN in every possible direction. They support that the

need of a multiple controller systems is really important and can help the adaption of SDN from the market.

Research Question 2: *Which business model framework best supports the design of an SDN business model?*

We answered the second research question in the third chapter. Academia offers many different business model frameworks and after a comparison of three of them we support that STOF framework best supports the design of our business model. We based our answer on the paper of (Zolnowski, Semmann, & Böhmann, 2011) which recommend five attributes (Applicability, Complexity, Focus on value proposition, Co-creation, Value in use) for comparison of business model frameworks. More analytically, we concluded that STOF is a framework that is focusing on value networks and ICT services. It is designed for service innovation and business models design and has a structured process to enhance the sustainability of a model. Additionally STOF is making use of CDIs and CSFs, which are tools helpful for the designer.

Research Question 3: *Based on the selected business model framework, how does a viable business model that integrates SDN technology in an IT service provider's datacenter infrastructure, looks like?*

The third research question was answered in the fifth chapter of the master thesis. For its answering was made use of all the four previous chapters of the thesis that are regarded to be preparatory for the completion of the business model. In chapter two the state of the art of SDN was made clear in order to enhance the design of the SDN service as well as the technical architecture of it. In chapter three the necessary business model framework was chosen and in chapter four our business model's research design was made explicit together with all the limitations and requirements needed for a viable design. Much more detailed answer to the question was given already some pages above. So we believe that referring again in detail in our SDN business model and answering the third research question again is not necessary. Plus all the details of it and all of its design steps can be found in chapter five.

So after we answered all three research questions of this thesis, we are now able to give an answer to main research question too:

Which would it be a business model for integration of SDN services in an IT service provider's service portfolio?

The main research question is mainly covered from the third research question of our thesis. So we will skip rephrasing of what was mentioned for the answering of the third research question.

But we believe that is of a major importance to refer to some of the attributes that a business model for integrating SDN services in an IT service providers shall have. These attributes are the following ones:

It has to be based on the state of the art of the SDN technology. So to give the competitive advantage to the company that will make use of it, as well as be future proof and compatible with future updates of the technology. This means that the business model should at least include an SDN

solution that is based on a multiple controller system that is based on open source software, which are provided from established vendors.

Additionally we believe that an SDN business model that is to be used from an IT service provider shall be based on a business model framework that is oriented for design of ICT services and has the capability to support analysis of value networks. Much more the chosen framework shall have a structured process for the design of the business model, in which critical success factors (CSFs), critical design issues (CDIs), or even key performance indicators (KPIs) shall be researched too. A framework like this may well be the STOF business model framework of (Bouwman, De Vos, & Haaker, 2010).

More specifically, for the case of designing a business model based on the novel technology of SDN the CFS and CDIs that shall be used we believe that are the ones in the following table:

CSFs / CDIs	clearly defined target group	compelling value proposition	acceptable quality of service	acceptable risks	acceptable division of roles	lowered service prices
	targeting of customers	bundle composition	security	acceptance of a non-proven technology	network complexity	automation of processes
		services integration	delivered value	technology robustness enhancement	actors selection	internal re-organization

Table 12- CSFs and CDIs for design of SDN services

Last but not least, a business model shall always has a last design step where the robustness of the designed business model could be tested, and risk mitigation strategies for some probable negative scenarios could be made.

6.1.2 Contribution

Theoretical

We believe that the theoretical contribution of this master thesis to the academia is threefold.

First, we contribute with an extensive survey for SDN that regards its current and future trends in the industry and academia. Tenths of papers are cited and a comprehensive outcome is reached. SDN researchers as well as any academic interested in the domain of computer networks can read our second chapter and get informed for the current state and future trends of SDN.

Second, we are expanding the STOF framework's external validity by making use of it in the domain of computer networks and more specifically in the technology of SDN. Much more, we defined which shall be the CSFs and CDIs for its design as well.

Third, the business model that we designed is probably the first one to be designed in this field of academia. This is a first step for the initiation of this novel research domain.

Practical

Our research was conducted in collaboration with the Dutch branch of the IT service provider Capgemini. Although, we believe that the business model we designed could be generalized easily so to be applied to other large IT service providers like Capgemini.

Much more, we believe that this master thesis could be of help for researchers that seek for the latest trends of SDN, as they can read the second chapter of this thesis and get well informed about this field. The entire thesis can be helpful for those that want to design a business model oriented to IT services as well. As they can get a basic understanding of how a business model in the domain of IT, and especially of computer networks, is designed.

Much more, as it is discussed through the thesis, SDN is not a broadly used technology and not many companies are taking advantage of its benefits. Our thesis functions as an evangelist of SDN and tries to find ways to exploit the technology in its early state by mitigating all the risks that have to be taken.

Last but not least our research project makes clear which are the necessary stakeholders for the provision of the service, which are the risks that an IT service provider can take in order to provide the service, which is the technical architecture that should adopt and of course which will be the added value for each one of the stakeholders.

6.1.3 Limitations

As mentioned above as well, our research is contacted in collaboration with Capgemini Netherlands. This fact allowed us to have access to abundant information into technical and business reports of the company, as well as enabled the discussions – interviews with many of the company's employees, which gave their insight for our business model's design.

So, the model that we designed is inevitably based on the organizational structure of Capgemini and in general many of the decisions taken are enabled from the global footprint of Capgemini, its brand name and the strong worldwide partnerships. So for cases that are having much different characteristics than this, might be difficult to customize our business model in their own needs.

6.1.4 Reflection

Having completed the SDN business model, allows us to comment on what could have been done better. Based on the concept of bounded rationality (Simon, 1982), we believe that we have made the best possible decisions for the time and information we had at our disposal.

Although, if this project was to be made from scratch we would have included more interviewees in the steps of the CSFs and CDIs evaluation as well as on the final step of the robustness check. This would have allowed to have a better overview of the domain, especially if the interviewees where external participants and not employees of Capgemini.

Moreover, another issue to be altered would have been our approach with the research of the SDN domain. We focused a lot on how the academia sees SDN. During our interviews with SDN professionals and experts we realized that there is the "academic SDN" and the "SDN of the industry". Each infrastructure vendor is having its own interpretation of SDN and offers its own differentiated solutions. Still by focusing more on the academic SDN we kept the academic validity of our project high and we offered to the academia a complete overview of the domain.

6.2 Practical Recommendations to the IT service provider

In this segment we are going to give some practical recommendations to any IT service provider that is willing to make use of our business model in order to provide SDN services to its customers.

Further than the designed business model itself that is fully analyzed in chapter 5, we have some more general proposals to make.

As discussed in the first chapter of the thesis, based on the paper of (De Reuver, Bouwman, & MacInnes, 2009), the phases that a business model is passing through to its maturity are three. First is the development/ R&D phase, next comes the implementation/ roll-out phase and finally is the commercial phase. Our business model is focused on the commercial phase, so as to enable an IT provider to deliver SDN services in the short term, given the fact that has the budget and the knowledge to upgrade its datacenters to the SDN architecture. Of course for this to happen, first the IT provider has to at least pass through the phase of implementation/ roll-out if we regard that SDN technology is ready to be utilized and no further research is necessary. So some more steps have to be made before our business model can be realized. Additionally, in the same paper the authors mention that there are three factors that influence the dynamics of the business model from phase to phase. These factors are regulation, technology and market and they play equal role for all the phases in the case of large enterprises, such as Capgemini. This means that the IT providers in each one the phases shall equally weight their choices based on the abovementioned factors.

(Accenture, 2013) mention SDN as "the last mile of virtualization" and proposes a road map for the integration of the service in a large enterprise. The plan of Accenture has two milestones, one in three months from the initiation of the process and the next a year later. The two steps can be liken as the first two phases of (De Reuver, Bouwman, & MacInnes, 2009). What Accenture proposes for the development/ R&D phase, and the Implementation/ Roll-out phase can be seen in the next figure that we designed. The figure combines the findings of or research with the proposals of (Accenture, 2013).

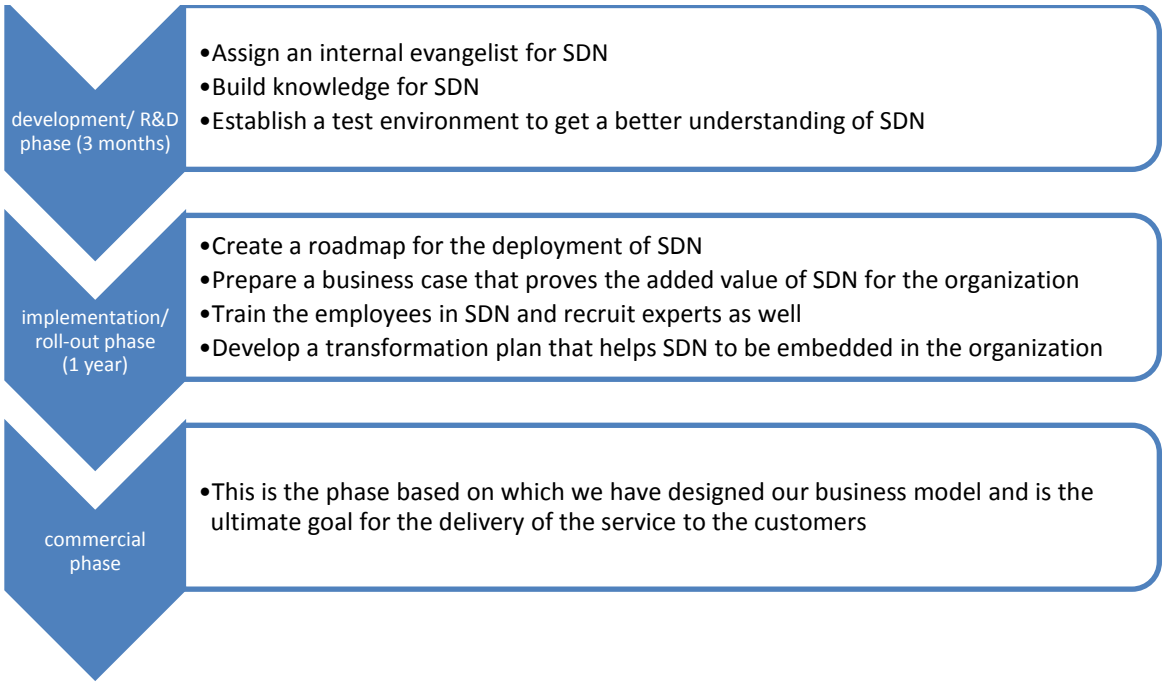

Figure 24 – Steps to maturity of the SDN business model

Following this steps, and as it was already discussed during our business model's design, Capgemini can be a fast follower of SDN technology and seize all the second-mover advantages from it as well as benefit from the lessons learned from the growing pains of the first-movers (Anthony, 2012).

Of course further research has to be done for the dynamics of the business model and this is discussed in the next section of this chapter.

Related with the technical domain of the business model, we like to recommend any interested to SDN IT service provider to follow the technical architecture that is proposed by the chosen infrastructure vendor. Plus, if possible to avoid mixing different vendor solutions. Following the vendor's proposed architecture can help an IT provider to have better support from the infrastructure vendor. Innovative implementations of SDN into the datacenters of IT providers, might create confusion and increase the complexity in case of troubleshooting. Especially in this early stage of SDN that the technology is not mature yet and it is regularly updated, it might be a good choice to follow the directions of the established infrastructure vendors. As for the limitation of not mixing infrastructure equipment of different vendors, this is a concern for interoperability issues. Since the standardization of SDN's enabling algorithms is still on an early phase and almost each one of the established vendors is promoting a slightly different SDN solution to the market, maybe it is rational to just contract only one vendor. We believe that the combination of these two tactics may save from a lot of trouble any IT provider.

Regarding the provisioning of the SDN service to the customers of the IT provider, as we discussed through our model as well, the complexity of the provided services should be escalated by the time. Initially, the bare essentials of the SDN service will be provided to the customers and little by little as the employees of the provider will acquire expertise on the SDN field will be easier for them and less risky for the provider to deliver complex SDN services. As proposed by (Accenture, 2013), training in advance most of the network engineers is a must and will help in the smooth transition to the SDN era.

Last but not least the reluctance of the customers to adopt SDN solutions can be decreased by lowering the prices that they are charged for the provisioned services. In any case SDN can lower the internal expenses of an IT provider. So there will be margin for revenue generation and reduction of the charged prices as well. Another tactic to reduce the risks that the customers believe that are taking with SDN, is to promote the SDN services through the sales and portfolio management teams. These teams can act as evangelists of the novel services and promote their benefits to the customers of the IT provider. Much more, promoting in the same time the brand name that an IT provider has in the industry as well as the partnerships that has with globally recognizable software and hardware vendors, enhances the credibility of the services and adds value for the customer. Much more, these last factors are creating confidence to the customers, as they allow them to be both financially and operationally covered in cases of disrupted service provisioning.

6.3 Future Research

Having researched what we focused on as derived from our scope, we got to realize that there are some open research domains on which further research can be done.

Firstly and as stated in the previous subchapter, further research has to be done related with the dynamics of an SDN business model focused on a large IT service provider. We focused on the commercial phase in order to set a goal of how a business model have to look like for an IT provider that intents to provide SDN services. But there is a research gap of how the IT provider will reach this point. So an analytical roadmap has to be designed in order to give a better understanding to a large corporation of how the transition to the SDN era will become reality.

Secondly, the SDN architecture will bring many changes in the business processes of an organization. Many of the network processes will be automated and some of the OLAs and SLAs will have to be updated or even taken away. Further research can give an insight of how the new business processes inside an IT provider will look like after the integration of SDN in its datacenters. Much more interest this case has, if we give a look to the business case of (ACG Research, 2013) which supports that SDN enables cost savings of 83% in the process of a service's creation and insertion to the system of the customer.

And thirdly, the continuous evolution of SDN's state of the art is a topic to be researched from any researcher that wants to generate a viable and feasible business model, and not only. SDN is a dynamic technology that is still formulated and many more services are going to be based on its architecture. So the constant monitoring of its development is essential.

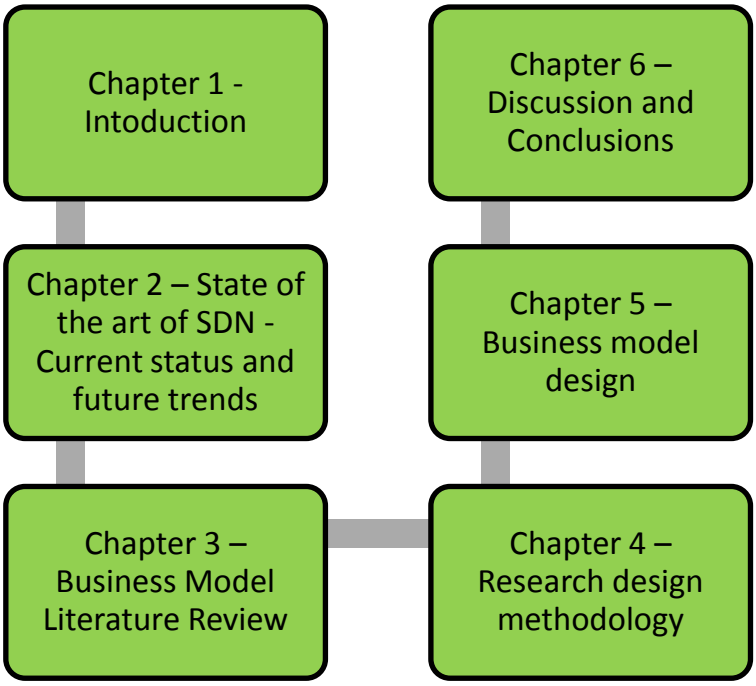

Figure 25 - Flow visualization of thesis' chapters. With green is marked the current chapter and state of research.

References

A10 Networks. (2014). *A10 Networks*. Retrieved July 15, 2014, from http://www.a10networks.com/

Accenture. (2013). *Accenture Technology Vision 2013.* Accenture.

ACG Research. (2013). *Business Cases for Brocade SDN Use Cases.* ACG Research.

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic management journal, 22(6-7)*, pp. 493-520.

Ammenwerth, E., Iller, C., & Mansmann, U. (2003). Can evaluation studies benefit from triangulation? A case study. *International journal of medical informatics, 70(2)*, 237-248.

Andersen, E. (2013). Schumpeter's core works revisited. *Long Term Economic Development*, 9-31.

Anthony, S. (2012, June 14). *First Mover or Fast Follower?* Retrieved from HBR Blog Network: http://blogs.hbr.org/2012/06/first-mover-or-fast-follower/

AXELOS. (2011). *ITIL® glossary and abbreviations.* AXELOS.

Ballon, P. (2007). Business modelling revisited: the configuration of control and value. *info, 9(5)*, 6-19.

Banks, E. (2013, February 26). *Will SDN Kill TRILL?* Retrieved July 15, 2014, from http://www.networkcomputing.com/networking/will-sdn-kill-trill/a/d-id/1234094?

Barney, J. (2001). The resource based view of the firm: Ten years after 1991. *Journal of Management, 27(6)*, pp. 625–641.

Big Switch Networks. (2014). *SDN Technology by Big Switch Networks*. Retrieved April 15, 2014, from Big Switch Networks: http://www.bigswitch.com/company/sdn-technology

Bouwman, H., De Vos, H., & Haaker, T. (2010). *Mobile service innovation and business models.* Berlin: Springer.

Braga, R., Mota, E., & Passito, A. (2010). Lightweight DDoS flooding attack detection using NOX/OpenFlow. *IEEE 35th Conference in Local Computer Networks (LCN)* (pp. 408-415). IEEE.

Brocade. (2014). *Ethernet Fabrics*. Retrieved September 17, 2014, from Brocade: http://www.brocade.com/solutions-technology/technology/ethernet-fabric/index.page

Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British dental journal, 204(8)*, pp. 429-432.

Business model generation. (2014). *Business model generation*. Retrieved 3 1, 2014, from Business model generation: http://www.businessmodelgeneration.com/

Business Wire. (2013, June 17). *Pica8 SDN Solution Powers University of Illinois' Network Research Lab* . Retrieved May 9, 2014, from Business Wire:

http://www.businesswire.com/news/home/20130617005567/en/Pica8-SDN-Solution-Powers-University-Illinois%E2%80%99-Network#.U2zMbihgO70

Capgemini. (2013, July 17). *Capgemini signs an extensive Infrastructure Outsourcing agreement with Kadaster* in the Netherlands*. Retrieved July 2014, 17, from http://www.capgemini.com/news/capgemini-signs-an-extensive-infrastructure-outsourcing-agreement-with-kadaster

Capgemini. (2014). *Cloud Services*. Retrieved June 23, 2014, from Clair: http://www.nl.capgemini.com/cloud-services/clair

Capgemini. (2014). *Infrastructure Outsourcing*. Retrieved June 23, 2014, from Capgemini: http://www.capgemini.com/infrastructure-services/infrastructure-outsourcing

Capgemini. (2014). *Remote Infrastructure Management*. Retrieved July 22, 2014, from http://www.capgemini.com/infrastructure-services/remote-infrastructure-management

Carr, N. G. (2003). IT doesn't matter. *Educause Review 38*, 24-38.

Casadesus-Masanell, R., & Ricart, J. (2011). How to design a winning business model. *Harvard Business Review, 89(1/2)*, pp. 100-107.

Casado, M., Freedman, M., Pettit, J., Luo, J., McKeown, N., & Shenker, S. (2007). Ethane: Taking control of the enterprise. *ACM SIGCOMM Computer Communication Review 37(4)*, 1-12.

Cisco. (2014). *epn roadshow 2014*. Retrieved May 2, 2014, from Cisco: http://www.cisco.com/web/offer/usc/epnroadshow_2014/index.html

Creswell., J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches.* Sage publications.

CRN. (2013, July 2013). *The 10 Coolest Networking Startups Of 2013 (So Far)*. Retrieved May 9, 2014, from CRN: http://www.crn.com/slide-shows/networking/240157961/the-10-coolest-networking-startups-of-2013-so-far.htm/pgno/0/6

Crunchbase. (2014). *Big Switch Networks*. Retrieved May 9, 2014, from Crunchbase: http://www.crunchbase.com/organization/big-switch-networks

De Reuver, M., Bouwman, H., & Maclnnes, I. (2009). Business model dynamics: a case survey. *Journal of theoretical and applied electronic commerce research 4(1)*, pp. 1-11.

Denzin, N. (1970). *Strategies of multiple triangulation, in: N. Denzin (Ed.), The Research Act. A Theoretical Introduction to Sociological Methods.* Chicago: Aldine.

Doyle, L. (2013, February 7). *Forecast: sizing the software-defined networking market*. Retrieved from Gigaom: http://research.gigaom.com/report/forecast-sizing-the-software-defined-networking-market/

El Sawy, O., & Pereira, F. (2012). *Business Modelling in the Dynamic Digital Space: An Ecosystem Approach.* Springer.

El Sawy, O., & Pereira, F. (2013). VISOR: A Unified Framework for Business Modeling in the Evolving Digital Space. In *Business Modelling in the Dynamic Digital Space* (pp. 21-35). Berlin Heidelberg: Springer.

Erickson, D. (2013, February 4). *What is Beacon?* Retrieved May 2, 2014, from Beacon: https://openflow.stanford.edu/display/Beacon/Home

ETSI. (2014). *ETSI*. Retrieved May 8, 2014, from Network Functions Virtualisation: http://www.etsi.org/technologies-clusters/technologies/nfv

F5 Networks. (n.d.). *F5*. Retrieved July 15, 2014, from https://f5.com/

Faber, E., & de Vos, H. (2010). *Creating Successful ICT-Services.*

Gambardella, A., & McGahan, A. M. (2010). Business-model innovation: general purpose technologies and their implications for industry architecture. *Long Range Planning 43*, pp. 262-271.

Gartner. (2013). Hype Cycle for the Telecommunications Industry.

Gartner Inc. (2014, February 18). The Top 10 Strategic Technology Trends for 2014.

GENI. (2014). *GENI*. Retrieved May 7, 2014, from About GENI: http://www.geni.net/?page_id=2

Grimble, R., & Wellard, K. (1997). Stakeholder methodologies in natural resource management. A review of principles, contexts, experiences and opportunities. *Agricultural Systems Journal 55(2)*, 173-193.

Gustafsson, A., Kristensson, P., & Witell, L. (2011). The Dimensions of Co-Creation and its Contribution to Market Success. *Proc. 12th Int. Reseach Symposium on Service Excellence in Management*, pp. 494-503.

Handigol, N., Seetharaman, M., Flajslik, A., Gember, N., McKeown, G., Parulkar, G., . . . Anderson, T. (2011). Aster*x: Load-Balancing Web Traffic over Wide-Area Networks.

Handigol, N., Seetharaman, S., Flajslik, M., McKeown, N., & Johari, R. (2009). Plug-n-Serve: Load-balancing web traffic using OpenFlow. *ACM SIGCOMM Demo.*

Hawkins, R. (2002). The phantom of the marketplace: Searching for new E-commerce business models. *Communication & Strategies, 46(2)*, pp. 297–329.

Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change, 74(4)*, pp. 413-432.

IETF. (2014, April 25). *Forwarding and Control Element Separation (forces)* . Retrieved April 29, 2014, from IETF: http://datatracker.ietf.org/wg/forces/

Investopedia. (2014). Retrieved August 17, 2014, from http://www.investopedia.com/terms/o/operating_expense.asp

Investopedia. (2014). *Investopedia*. Retrieved August 17, 2014, from http://www.investopedia.com/terms/c/capitalexpenditure.asp

Kadaster. (2013). *Kadaster*. Retrieved 23 2014, June, from http://www.kadaster.nl/web/over-kadaster/Pers/Persbericht/Kadaster-en-Capgemini-tekenen-uitbestedingsovereenkomst.htm

Kajko-Mattsson, M., Ahnlund, C., & Lundberg, E. (2004). CM 3: service level agreement. *20th IEEE International Conference on Software Maintenance* (pp. 432-436). IEEE.

Lakshman, T., Nandagopal, T., Ramjee, R., Sabnani, K., & Woo, T. (2004). The softrouter architecture. *ACM SIGCOMM Workshop on Hot Topics in Networking.*

Lara, A., Kolasani, A., & Ramamurthy, B. (2013). Network innovation using openflow: A survey. *IEEE Communication Serveys & Tutorials*.

Layer123. (2014). *layer123*. Retrieved 2014, from layer123: http://www.layer123.com/sdn

Leary, M. (2014). *SDN, NFV, and open source: the operator's view.* Gigaom.

Leiserson, C. (1985). Fat-trees: universal networks for hardware-efficient supercomputing. *IEEE Transactions on Computers 100(10)*, pp. 892-901.

Liaros, P. (2014). *The Software-Defined Networking Architecture and its business model from the IT service provider's perspective.* Delft.

Liu, P. H. (2013). The Way towards SDN and NFV: Think Big, Start Small. *Huawei Technologies*.

Martin, M. (1994). *Managing Innovation and Entrepreneurship in Technology-based Firms.* Wiley-IEEE.

Matsumoto, C. (2010, December 15). *LightReading*. Retrieved July 15, 2014, from A10 Countersues F5: http://www.lightreading.com/spit-%28service-provider-it%29/packet-inspection-traffic-management/a10-countersues-f5/d/d-id/682533

Matsumoto, C. (2012, October 8). *6 SDN Startups to Watch*. Retrieved May 9, 2014, from Light reading: http://www.lightreading.com/carrier-sdn/sdn-architectures/6-sdn-startups-to-watch/d/d-id/697627

McGillicuddy, S. (2014, May 1). *Pica8 claims to be first vendor to support OpenFlow 1.4*. Retrieved May 9, 2014, from Techtarget: http://searchsdn.techtarget.com/news/2240214709/Pica8-doubles-flow-rule-capacity-in-its-new-OpenFlow-13-switch

McKeown, N., Anderson, T., Balakrishnan, H., Parulkar, G., Peterson, L., Rexford, J., & Turner, J. (2008). OpenFlow: enabling innovation in campus networks. *ACM SIGCOMM Computer Communication Review 38(2)*, 69-74.

Mendonca, M., Astuto, B., Nguyen, X., Obraczka, K., & Turletti, T. (2013). A survey of software-defined networking: Past, present, and future of programmable networks.

Miller, D., & Shamsie, J. (1996). The resource based view of the firm in two environments. The hollywood firm studios from 1836 to 1964. *Academy of Management Journal, 39(3)*, pp. 519–54.

Nadeau, T., & Gray, K. (2013). *SDN: Software Defined Networks.* O'Reilly Media, Inc.

Nickle, M. M. (2014, January 31). *New ONF membership category opens door to startup SDN companies*. Retrieved May 2, 2014, from Techtarget: http://searchsdn.techtarget.com/news/2240213573/New-ONF-membership-category-opens-door-to-startup-SDN-companies

NOXRepo.org. (2014). *NOXRepo*. Retrieved May 2, 2014, from http://www.noxrepo.org/nox/about-nox/

ONF. (2014). *Customer Case Studies* . Retrieved May 8, 2014, from ONF: https://www.opennetworking.org/sdn-resources/sdn-library/customer-case-studies

Open Network Summit. (2013). *Why Attend*. Retrieved Febraury 24, 2014, from Open Network Summit: http://www.opennetsummit.org/why-attend.html

Open Networking Foundation. (2013). *OpenFlow Switch Specification.* Open Networking Foundation.

Open Networking Foundation. (2013, April 13). Software-Defined Networking: The New Norm for Networks, ONF White Paper. Retrieved from https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/wp-sdn-newnorm.pdf

Open Networking Foundation. (2014). *Open Networking Foundation Member Listing*. Retrieved April 17, 2014, from Open Networking Foundation: https://www.opennetworking.org/membership/member-listing

Opendaylight. (2014). Opendaylight Project - Hydrogen. Retrieved from http://www.opendaylight.org

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook For Visionaries, Game Changers, And Challengers.*

Parulkar, G. (2014, March 3). *How Open [Compute, Network, Source] will Shape Future of Computing and Networking?* Retrieved from Open Networking Summit: http://www.opennetsummit.org/archives-ons/archives-2014/

Pfeffer, J., & Salancik, G. (1978). *The external control of organizations. A resource dependence perspective.* New York: Harper & Row.

Porter, M. (2001). Understanding Business Processes. In *The value chain and competitive advantage.* Routledge.

Project Floodlight. (2014). *Project Floodlight*. Retrieved May 2, 2014, from Project Floodlight: http://www.projectfloodlight.org/

Ren, T., & Xu, Y. (2014). Analysis of the New Features of OpenFlow 1.4. *2nd International Conference on Information, Electronics and Computer.* Atlantis Press.

Sakaguch, T., Nicovich, S., & Dibrell, C. (2004). Empirical evaluation of an integrated supply chain model for small and medium sized firms. *Information Resources Management Journal 17(3)*, 1–19.

SBA - EU. (2013). *2013 SBA Fact Sheet - Netherlands.* EU.

SDNRG. (2014). *Software-Defined Networking Research Group (SDNRG)*. Retrieved April 30, 2014, from Internet Research Task Force (IRTF): https://irtf.org/sdnrg

Selten, R., & Gigerenzer, G. (2002). *Bounded Rationality: The Adaptive Toolbox.* MIT Press.

Sezer, S., Scott-Hayward, S., Chouhan, P., Fraser, B., Lake, D., Finnegan, J., & Rao, N. (2013). re we ready for SDN? Implementation challenges for software-defined networks. *Communications Magazine, IEEE*.

Simon, H. A. (1982). *Models of bounded rationality: Empirically grounded economic reason (Vol. 3).* MIT press.

Smith, C. P. (2000). *Content analysis and narrative analysis. Handbook of research methods in social and personality psychology. p.313-335.*

Staessens, D., Sharma, D., Colle, M., Pickavet, M., & Demeester, P. (2011). Software defined networking: Meeting carrier grade requirements. *18th IEEE Workshop on Local Metropolitan Area Networks (LANMAN).* IEEE.

Stretch, J. (2013 , May 2). *Packetlife*. Retrieved July 10, 2014, from What the Hell is SDN?: http://packetlife.net/blog/2013/may/2/what-hell-sdn/

Tanenbaum, A., & Wetherall, D. (2011). *Computer Networks, 5th Edition.* Pearson.

Techtarget. (2013, November). *Data center network design moves from tree to leaf*. Retrieved September 17, 2014, from Techtarget: http://searchdatacenter.techtarget.com/feature/Data-center-network-design-moves-from-tree-to-leaf

Teece, D. J. (2010). Business Models, Business Strategy, and Innovation. *Long Range Planning 43*, pp. 172-194.

Tongo, M. (2007). Purposive Sampling as a Tool for Informant Selection. *Ethnobotany Research & Applications, 5*, pp. 147-158.

Vaishnavi, V. K., & Kuechler, W. J. (2007). *Design science research methods and patterns: innovating information and communication technology.* CRC Press.

Venkitachalam, K., & Busch, P. (2012). Tacit knowledge: review and possible research directions. *Journal of Knowledge Management, 16(2)*, 357-372.

Verschuren, P., & Hartog, R. (2005). Evaluation in design-oriented research. *Quality and Quantity, 39(6)*, pp. 733-762.

Verschuren, P., Doorewaard, H., & Mellion, M. (2010). *Designing a research project.* Eleven International Publishing.

vtracks. (2014). *vtracks*. Retrieved May 2, 2014, from vtracks: http://www.vtracks.nl/

Williams, A. (2012, July 23). *Techcrunch*. Retrieved April 27, 2014, from VMware Buys Nicira For $1.26 Billion And Gives More Clues About Cloud Strategy : http://techcrunch.com/2012/07/23/vmware-buys-nicira-for-1-26-billion-and-gives-more-clues-about-cloud-strategy/

Yao, B., Bi, J., & Xiao, P. (2011). Source address validation solution with OpenFlow/NOX architecture. *19th IEEE International Conference on Network Protocols (ICNP)* (pp. 7-12). IEEE.

Yap, K., Kobayashi, M., Sherwood, R., Huang, T., Chan, M., Handigol, N., & McKeown, N. (2010). OpenRoads: Empowering research in mobile networks. *ACM SIGCOMM Computer Communication Review 40(1)*, pp. 125-126.

Yin, R. K. (2009). *Case study research: Design and methods (Vol. 5).*

Zolnowski, A., Semmann, M., & Böhmann, T. (2011). Metamodels for representing service business models. *SIGSVC Workshop.*

Appendix

A1. Sample of interview's protocol

The following questions were asked during the external interviews that were focused on the design of the quick scanned service domain.

Customers and End Users:

- Who is the customer and who is the end user? (Who pays for the service and who is using it?)

Use Cases:

- Which are the use cases of SDN that makes you more interested?

Context of Use:

- When is the service useful to be utilized?

Intended/ Delivered value and value proposition:

- Why would you want to buy the service?
- What do you find new and innovative about it?

Previous experience, expected and perceived value:

- Do you use any alternative products or services?
- What do you like about them?
- And what do you dislike?
- What do you expect from these services in general?
- And you expect from the designed service in particular?

Rates

- Are you willing to pay extra for SDN services?
- Do you believe that in the long term it will save you money?

Effort

- Will the new service require from you extra efforts? (training, learning curve, etc)

A2. Technical terminology elaboration

In the following lines and before we start analyzing more complex concepts; terms that are discussed through this chapter, and the entire master thesis as well, are going to be analyzed in order to give a better understanding to the reader. More specifically, the OSI model, basic network entities and their enabling software, network interfaces and network topologies are going to be analyzed.

OSI model

OSI stands for Open Systems Interconnection, and is consisted of seven discreet layers. Each one of the layers is responsible for a different function in the communication between the network's entities. The seven layers, from bottom to the top, are the following: physical, data link, network, transport, session, presentation and application layer. The model is especially useful for many ICT professionals, since it is enabling standardization and interoperability in computer network's communication protocols. In the next figure the OSI model is depicted, and the way that two network entities are enabled to communicate is made visible.

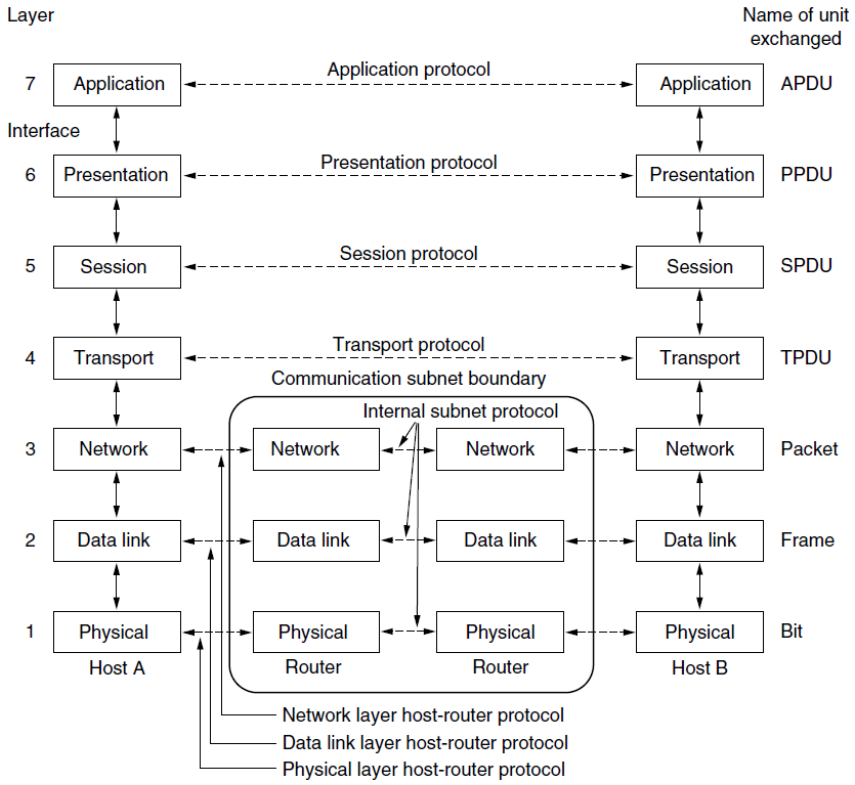

Figure 26 - OSI model (Tanenbaum & Wetherall, 2011)

Switches and Routers

These are the physical devices that are enabling the data transmission in the network. Both of them are vital for the functioning of a network. Switches are operating on the second OSI layer, on the contrary with routers that are operating on the third OSI layer. Routers and switches are having integrated software that is called firmware, and is responsible for their operations in the network. Firmware can be different from vendor to vendor but the main building blocks, that are called planes, are common. So firmware is consisted of the three basic entities of routing control plane, data plane and management plane. All three planes are briefly explained in the next three paragraphs:

I. Routing Control plane

Or for simplicity called just control plane, is the integrated part of firmware that is responsible for the design of the routing tables and the decisions of where the incoming packets will be transferred next. The main difference of a router and a switch in the control plane is that the router is making use of the IP headers while on the other hand a switch is using the MAC addresses.

II. Data plane

Sometimes called forwarding plane as well, is complementary to the control plane and vice versa. The data plane is responsible for the execution of control plane's commands. So it is handling all of the incoming datagrams and makes sure that they are forwarded to the right destination. Simultaneously the data plane is proceeding the incoming traffic based on the commands of the control plane. For example the data plane might have to silently drop some packages in order to keep the network safe from external cyber-attackers or from network overloads.

III. Management plane

Management plane is synonym to the user interface of a router/switch, which is responsible for the interaction with the administrator-user of it that enables him to program and customize its functions. The customization is made based on widely used protocols such as SNMP, Telnet, SSH, XML, etc.

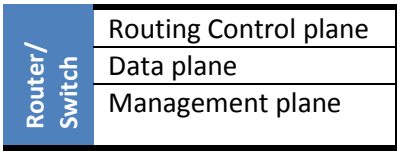

Figure 27 - Three planes of a router

SDN Controller

A controller is the responsible element for the smart networking concept of the software defined networks (SDN). It is responsible for the flow control of the network's traffic. There are many different implementations of controllers up to the moment; some of them proprietary and some others under free licenses. The SDN controllers are based on SDN enabling protocols that are allowing them to intelligently manage the whole network. One of the most popular SDN protocols is the OpenFlow protocol that is maintained from the Open Networking Foundation.

Northbound and Southbound interfaces

Network devices in order to communicate with the SDN controller and the high level applications, and vice versa, need specific interfaces. This vertical communication is made through the southbound and the northbound interfaces.

The southbound interface is allowing the two-way communication of the higher abstraction levels with the SDN controller. For example routers and switches, virtual and physical, can exchange information with the SDN controller through the southbound interface. On the other hand the northbound interface allows the two-way communication of lower instance abstractions with higher ones. For example firewalls, load balancers and other applications can be updated regarding the control information through the northbound interface.

As a result the two interfaces are cooperating in order to achieve a non-problematic communication in the network. When the interfaces are drawn in an architectural diagram, the northbound is drawn on the top of the component that is incorporated in. As for the southbound it is drawn on the bottom of the component. A better idea of the two interfaces could be given by the following figure. Important to be mentioned in this point is that in the SDN terminology all of the networks infrastructure i.e. switches, routers, etc, are called just switches.

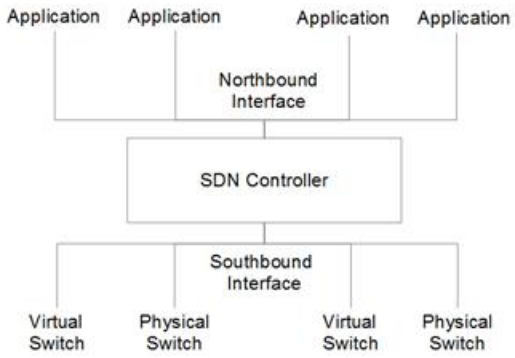

Figure 28 - SDN Interfaces

Logical and physical network topologies

The physical topology of a network is its physical structure; how the network infrastructure is designed and build, and how the network elements are connected between each other. On the contrary the logical topology of the network is how the data is flowing the network. Important is to be mentioned that maybe two networks seem identical based on their physical topology, but their logical topologies might be totally different.

A3. Popular SDN Events

In this segment are mentioned some notable events that are related with the SDN architecture and its deriving technologies. Conferences and congresses that are leading the advance of the SDN worldwide are mainly going to be discussed.

Open Networking Summit

For the last three years an annual Open Networking Summit is organized in cooperation with the ONF with increasing popularity in the telecommunications industry and the academia as well. The next summit, fourth in the row, was arranged to take place in Santa Clara - California from 3rd to 5th of March 2014. The projected attendees for the summit of 2014 are estimated to be approximately 2200, and the exhibitors are going to reach the number of 57 (Open Network Summit, 2013). These numbers are referred to indicate the growth of the SDN architecture in the market and the academia. Especially when the above numbers are compared with the ones of the first Open Networking Summit that took place in 2011, where the attendees were 409 and the exhibitors were 23 the growth of the interest for the technology is made clearer. The Chairman of the event is Dr. Guru Parulkar, which is the Executive Director of Open Networking Research Center and Consulting Professor of Electrical Engineering at Stanford University (Open Network Summit, 2013).

Important to be mentioned at this point is that during the last Open Networking Summit, Dr. Guru Parulkar in one of his presentation slides for his keynote speech during the opening of the summit, noted that SDN is still in the early adoption phase (Parulkar, 2014). The slide from the mentioned presentation can be seen in the next figure. Dr. Guru Parulkar in the same presentation characterized SDN as a disruptive innovation as well.

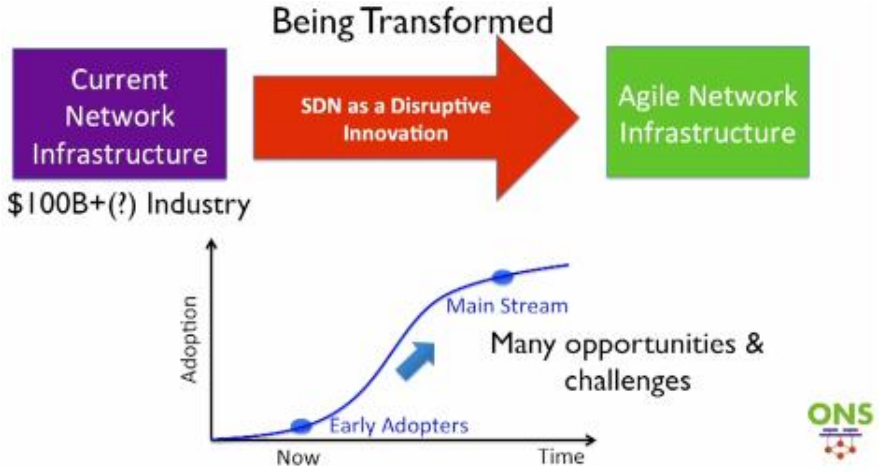

Figure 29 - Diffusion state of SDN (Parulkar, 2014)

SDN & OpenFlow World Congress

The SDN & OpenFlow World Congress is organized by the service provider Layer123. For the year 2014 it takes place during 14-17 October 2014 at Swissôtel Düsseldorf in Germany. The congress will be co-hosted by the ONF and host operator will be T-Mobile. The first Congress was held in 2012 and for this year it is expected that more than 1300 professionals and academics will join. Moreover more than 60 solution developers will participate and many will be the opportunities for the diffusion of the SDN's innovative ideas. (Layer123, 2014)

VMware and HP held events

VMware and HP are joining their forces and are presenting their solutions in common events in Netherlands. The lately organized “Software Defined Enterprise Roadshow” by VMware and HP took place on 4th of April 2014 and it covered the domains of end user’s computing, software-defined storage, cloud operations and of course software-defined networking. In order to promote their products and services as well as make an effort to expand the reputation of the technology the participation in the events is free. (vtracks, 2014)

Cisco held events

Cisco is organizing events worldwide as well, in order to promote its Evolved Programmable Network (EPN) solutions as well as its Application Centric Infrastructure (ACI). On a round the world presentation tour, the roadshow took place in Amsterdam, Netherlands on May 22-24 2014. The attendance to the roadshow of Cisco is free of charge, just like the competitive VMware and HP. (Cisco, 2014)

A4. Early adopters of the SDN Architecture

Some of the early adopters in the cloud provisioning market are Google, Microsoft, Yahoo! and Facebook. In the market of the service provisioning some of the early adopters are NTT Communications, Deutsche Telekom and Verizon. Last but not least, two early adopter enterprises are EBay and Goldman Sachs (Open Network Summit, 2013). Over the next lines some more cases will be analyzed and more information will be provided.

University campuses – Stanford University

In the paper of (McKeown, et al., 2008) it is clearly supported by the authors that the SDN architecture can enhance innovation and research in the university campuses. The authors mention as well that the implementation of SDN in a campus can allow the researchers to test through the whole campus of their universities under-development routing protocols by running experiments and testing scenarios. Important and of great importance as well, is that the SDN architecture allows all the mentioned testing and experimentation without interrupting the normal processes of the network or compromising the efficiency of it for the end users. So Stanford University from the early 2008 is using the SDN to interconnect the network facilities of its campus. The authors of the same paper at the moment if its publication were motivating the rest of the researchers around the globe to do the same. Till 2011 as it can be seen in the following image multiple universities and organizations as well joined the SDN community and implemented it in their own campuses as well.

Google's backbone network

Google is having its network organized in two backbones. The one is supporting the traffic generated by the users (I-scale) and the other is supporting the traffic between datacenters (G-scale). The G-scale is the one that Google took the decision to fully transform into an SDN. When Google took this decision no vendor had a solution to support the needs of Google; so Google build its own solution. The features supported by the solution were a few but enough to serve the needs of the company. Google wanted to have scalability in terms of terabits of bandwidth as well as fault tolerance. The OpenFlow protocol is used for the implementation of the custom SDN of Google. What Google has realized is a highly dynamic centralized traffic engineering service. The project started on January 2010 and it was finalized in the beginning of 2012. Now Google has utilization of its G-scale backbone of up to 95%, percentage that is really difficult to be achieved under other circumstances. (ONF, 2014)

NEC & Kanazawa University Hospital

The Kanazawa University Hospital has many departments and subdivisions and each one of them is in need of its own private network. Confidential data is stored in the servers of the departments and it has to be secured that this data will stay private in the future as well. This situation made the whole network of the hospital really difficult to manage; multiple sub networks with many security policies for each one of them made the situation complex. Moreover the addition of new nodes was made manually and the human factor many times proved to make costly mistakes for the hospital's network. So the hospital's network administrators had to give a solution to this problem.

The answer for them was to choose NEC's "UNIVERGE ProgrammableFlow" implementation. A network solution that is based on OpenFlow and it is regarded to be innovative and highly efficient. After the integration of the technology in the hospital's infrastructure, there is transparency of the network; since the ProgrammableFlow is giving a broad view of the network's physical and logical

structure. Moreover, each department can create secure virtual networks that are controlled centrally based on the philosophy of OpenFlow. This helps the interconnection of the different departments while all the sensitive data stays secure. Additionally, new devices connected to the network are made part of the logical and physical topology automatically. This is helping in the innovation of new technologies, such as wearable devices from patients and other advanced medical instruments. Last but not least, the hospital is getting benefited from load balancing techniques and bandwidth pre-allocation capabilities of the NEC's system. As the hospital's network administrators are stating, the image processing has become very demanding since the late medical equipment is generating high resolution images so they are pre-allocating bandwidth for the transfer of these images in order to have quicker diagnoses. (ONF, 2014)

A5. SDN startups

Big Switch Networks

Is a startup company founded in 2010 and is located in Mountain View, California. The company is producing bare metal switches, which are pure SDN switches and focuses on creating sophisticated SDN algorithms in order to gain the competitive advantage in the telecommunications market. Its focus is to free the customers from proprietary products and enable them to use any switch they want to by running SDN software on it. The company has achieved to rise 53 million dollars through venture capital investments (Crunchbase, 2014).

Big switch Networks was named by the Computer Reseller News as one of the 10 coolest networking startups of 2013 (CRN, 2013). Last but not least, one of the most popular SDN controllers in the market is developed from Big Switch Networks. The controller's project is called Floodlight and it is already mentioned in the section of the controllers' review.

Pica8

Pica8 is a startup company based in Palo Alto, California and it was founded in 2009. The company promotes open standards and wants to avoid selling expensive infrastructure that locks in the clients. Moreover Pica8 is publishing guides of how can a client use the solutions of the company and how it can get benefited. One of the most famous clients of the company is the University of Illinois at Urbana-Champaign, which recently bought SDN switches from Pica8 for its computer network research laboratories (Business Wire, 2013). Moreover, the company has been awarded many distinctions till now, but something really special about the company is that it is the first to support the newest version of the OpenFlow protocol, the 1.4 version. While many companies still sell switches that are only supporting the 1.0 version, Pica8 has accomplished to launch in the market a technological cutting edge switch. The vice president of marketing of Pica8 in one of his interviews he stated "We think we are about a year ahead of the rest of the networking community." (McGillicuddy, 2014).

Embrane

Embrane is a networking startup company based in Santa Clara, California. It was founded in 2009 and through two founding rounds accomplished to raise 32 million dollars of investments. Scope if Embrace is to virtualize the OSI layers of 4 to 7. OpenFlow has focused in virtualizing and software-defining the 2nd and as a physical trajectory the 3rd level of the OSI layers, but Embrace focuses more on higher levels. This can give the competitive advantage to the company and will for sure open new domains for research and new markets creation (Matsumoto, 2012).

Midokura

Midokura is an innovative Japanese networking startup. It is willing to create an all in one product that will virtualize all of the OSI levels from 2 to 7. This way the company's solution will overtake all of the other solutions that are launched in the market at the moment. Both OpenFlow and Embrace solutions' that are refereed here will be supplied from the Japanese company with this concatenated software implementation idea. Midokura has offered small parts of code for the OpenFlow as well but at the moment it is mostly busy with the implementation of its own disruptive idea. The company has gathered almost six million US dollars from Japanese investors, among them is the NTT Communications Corporation as well (Matsumoto, 2012).