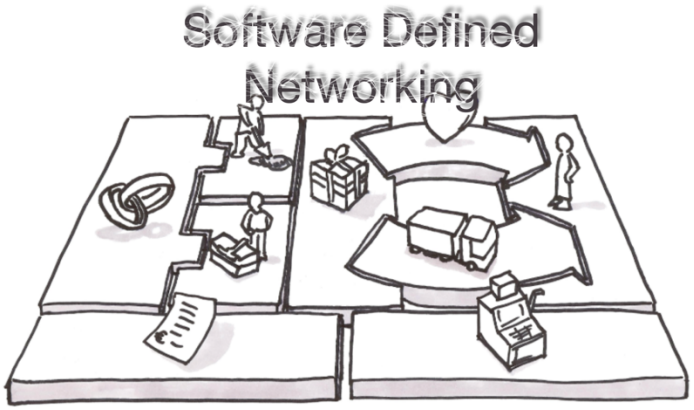
Exploring New Business Models for Software Defined Networking



Master Thesis
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Master Thesis

This document is a master thesis written within the business informatics master program of the Information and Computer Sciences department at Utrecht University. The research was conducted internally.

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Abstract

The business model concept is becoming an eye catcher in the information technology industry. Many IT companies are constructing their business models to keep competitive on the cutting edge of the technology world. However, when comes to new technology or an emerging market, it remains difficult for the decision maker to make an assertive choice. This paper aims to fill this gap to provide the companies with an overall approach to better design and develop business models in an innovative IT market. Business model canvas is utilized as a modeling method to analyze the existing players in the market, and method engineering is applied to develop new business models by reusing business model fragments from existing SDN providers in the market. Moreover, an industry first SDN solution model was proposed as a representation tool to bridge the business concept and the SDN functionalities. Our models and methods are evaluated and enhanced by interviewing experts from the nominated organizations. In addition, the method is applied to a case company for further evaluation. The approach of creating new business models in innovative IT market in this thesis is found to be appropriate and effective in analyzing existing SDN providers and reusing their business components into a new SDN strategy.

Table of Content

Glossary

Abbreviation	Description
SDN	Software defined networking
BMC	Business model canvas
PDD	Process deliverable diagram
NFV	Network functionality virtualization
QA	Quality attribute
ODL	OpenDaylight
VM	Virtual machine
vSwitch	Virtual switch
Eff. & Eff.	Effective and Efficient

In this document, “we”, “our”, “us” all stand for the authors of this thesis.

Chapter 1 Introduction

Contemporarily, the software defined networking (SDN) concept has been becoming a buzz word in the networking industry. SDN subverts the traditional design of network device by decoupling the controller plane and data forwarding plane so that it enables an application-centric networking solution rather than the primitive all-in-one network device architecture. The impact of SDN cannot be neglected. Thus, foreseeing SDN will play an essential role in the future networking industry, many networking providers started to join this emerging market.

Without much experience in this new market, managers and decision makers are uncertain which part of SDN should they focus on, which direction is the best-fit for the companies, and so on so forth. A business model is required to solve these problems. However, there is no previous evidence that a certain business model can match this new IT market. Hence, by investigating the SDN market and business model theory, the authors will uncover the main research questions in this chapter, and list some potential sub-research questions, which will be addressed and answered in the following chapters in the thesis.

1.1 Practical problem investigation

1.1.1 SDN market background

SDN, as one of the fastest growing business concepts for the networking industry, has created many successful examples in the data center cases, but current technology is still relatively immature (Skorupa, 2013). According to Gartner report[1], by the end of 2016, more than 10,000 enterprises worldwide will have deployed SDN in their network. Presented by Plexxi[2], Lightspeed Venture Partners[3], and SdxCentral[4], an SDN market size report also showed that the impact of SDN will exceed $25 billion per annum by 2018. Networking leader Cisco recently reported a 55%[5] sequential rise in the number of customers for their Nexus 9000 series switches[6] in Q2 FY, 2015. Indicating that a continued demand for their Software Defined Networking products, VMware, another software player, announced that there were over 400[7] paying customers for VMware NSX, its network virtualization platform for the Software Defined Data Center (SDDC). HP, who launched Industry's first SDN AppStore reported that the HP Virtual Application Networks (VAN) SDN Controller has been downloaded more than 3,000 times, and HP SDN Software Development Kit, which has been downloaded more than 5,000[8] times. According to SDx Central, SDN was placed to reach a compound annual growth rate of 80% from $3.5 billion in 2014 to $35 billion in 2018 (Figure 1-1). Similarly, the spending on the network for SDN rised sharply to corrode the traditional networking solutions. (Figure 1-2)

[1] http://blogs.gartner.com/andrew-lerner/2014/12/08/predicting-sdn-adoption/
[2] http://www.plexxi.com
[3] http://lsvp.com
[4] https://www.sdxcentral.com
[5] http://www.forbes.com/sites/greatspeculations/2015/03/25/networking-notes-cisco-vmware-juniper-and-the-sdn-market/
[6] http://www.cisco.com/c/en/us/products/switches/nexus-9000-series-switches/index.html
[7] http://www.forbes.com/sites/greatspeculations/2015/03/25/networking-notes-cisco-vmware-juniper-and-the-sdn-market/
[8] http://www8.hp.com/us/en/hp-news/press-release.html?id=1798074#.VZ-YBM6Si7M

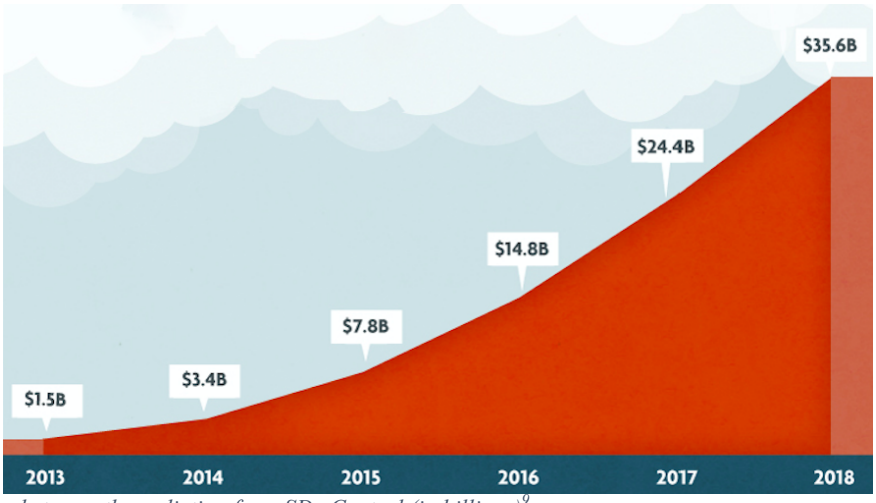

Figure 1-1. SDN market growth prediction from SDx Central (in billions)[9]

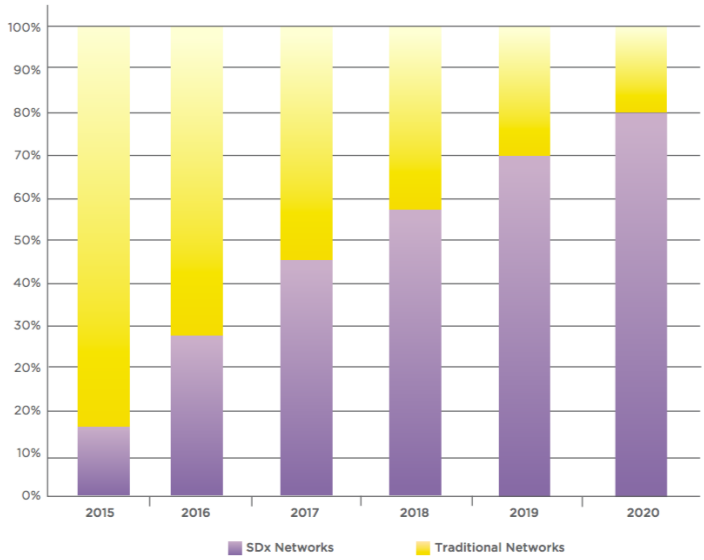

Figure 1-2. Portion of network purchase influenced by SDN networking (2015 SDN and NFV market size and forecast report, 2015)

However, SDN consists of a large part of components, such as SDN controller, network virtualization, NFV[10], network orchestration, network device, virtual network device, open source SDN product, and so forth. The complexities raised various barriers for companies to invest and develop their SDN strategies to adapt the networking revolution. Moreover, little literature or report has shown that whether traditional operators will easily switch to SDN or will new entrants take over the market. Therefore, it becomes challenging to have a clear vision for the SDN market, as well as to pursue a breakthrough networking technology. In other words, to design and develop a suitable business model to better understand and extend SDN business is becoming challenging.

[9] https://www.sdxcentral.com/articles/announcements/sdn-market-sizing/2013/04/

[10] https://www.sdxcentral.com/resources/nfv/whats-network-functions-virtualization-nfv/

1.1.2 Impact

The lack of a generic business model, which restrains companies to hold an overview and vision for the SDN market, will decelerate companies from catching up with the newest technologies. As a consequence, it will inhibit a healthy business development in the SDN market. For a big company, a few steps behind means a substantial impact on the future business competition. Similarly, a startup will fail quickly without a valuable SDN business model to keep them in the the correct directions.

1.2 Business model background

In a booming IT market, new technologies usually provide promising opportunities for companies. For examples, multi-touch technology for the big - screen mobile phone industry, e-commerce for the retailer business and many other cases. All of those technologies reinvented the way of doing business and bred a plenty of successful companies. However, it is hard to foresee how the technology will evolve during the time (Sood, James, Tellis & Zhu, 2012). Rosenberg (1997) stated that a new technology may turn out to be worthless, even a failure or spin out in an unexpected direction. Hence, confronting continuous challenges in an innovative IT market, in which, requires the capabilities of entrepreneurs to design and build up a strategy to ensure the full potential of the technologies. It is widely believed that business models can determine the success of an electronic venture (Alt & Zimmermann, 2001). A good business model is considered another key to success besides the core technology. According to Chesbrough (2010), the pecuniary value of new technologies usually remains latent at the beginning stage until it is commercialized in some forms through a business model. In other words, an advanced technology cannot stand alone for a company, especially for a startup, to achieve its economic value. Chesbrough and Rosenbloom (2002) stated that a successful business model generates a holistic logic that combines the cutting edge technologies with the realization of economic value. In a subsequent research, Chesbrough (2007) stated that innovation must include business model, rather than just technology and R&D. Furthermore, such business models are recently becoming a form of intellectual property. For examples[11], Amazon's patent of 5,960,411 -- Method and system for placing a purchase order via a communications network (One-click purchase), eBay's 6,415,320 -- Information presentation and management in an online trading environment and Netflix's 6,584,450 -- Method and apparatus for renting items.

Based on the literature above, the authors believe that a reliable business model can accelerate the growing of a tech-company. Additionally, some researchers have made contributions by proposing business models in the innovative IT industry. Mahadevan (2000) put forward a three-dimensional framework for defining a business model and apply it to the Internet based business. They also identified certain factors that guide the enterprise to make the appropriate choices when developing their business models. Chesbrough and Rosenbloom (2002) explored the role of the business model in capturing values from the early stage technology. They not only studied the root of the business model concept but also offer an empirical case study on Xerox to show how this company rose by implementing an effective business model to make a profit from a technology that was abandoned by other leading companies.

[11] http://digitalenterprise.org/ip/patented_models.html

Business model is defined as "a model that delineates the rationale of how an organization creates, delivers, and captures value" in the book "Business model generation" (Osterwalder & Pigneur, 2010). In essence, it depicts the way in which an enterprise delivers values to customers, how it entices its customers to pay for these values and how these payments are converted into profits. Over last two decades, there was a rapid growth in the study of business models (Zott, Amit & Massa, 2011). Timmers (1998) provided a classification of eleven business models for electronic commerce, both business-to-business and business-to-consumer, which are essentially helpful to the re-implementation of traditional forms of doing business at that time. Gordijn and Akkermans (2001) presented a comprehensive conceptual modeling approach to e-business, which defines the economic value within a network of actors. Their e^3-value methodology can provide a revenue stream, value objects, customer ownership, price setting, alternative actors and partnership issues, which are turned out to be especially useful in articulating e-business ideas precisely. Petrovic, Kittl and Teksten (2001) introduced a theory-based methodology for developing e-business business models, which was elaborated at evolaris (An Austrian joint venture of major enterprises from different industries) and were being validated later on in various business cases. Alt and Zimmermann (2001) studied the existing approaches and definitions and put forward a model that differentiates six business model elements. Morris, Schindehutte and Allen (2005) create a six-component framework for characterizing a business model at three different levels. Furthermore, they claimed that the business model can be an essential construct in an enterprise (Morris, Schindehutte & Allen, 2005)

1.3 Problem statement

The existing significant amount of literature provided a rich knowledge of various parts of business models, all of which intend to explicitly define how organizations fulfill their missions and commercial activities ((Gordijn & Akkermans, 2001); (Rappa, 2002); (Weill & Vitale, 2002)). According to Muhtaroglu, Demir, Obali and Girgin (2013), these studies vary in several aspects. For instance, some of them provided a set of tools and visualization methods to design business models (Gordijn & Akkermans, 2001) whereas some studies provided definitions and classifications of the business models (Rappa, 2002), such as Brokerage, Advertising, Infomediary, Merchant, Manufacturer (Direct) and Affiliate. Moreover, some studies proposed the evaluation metrics to assess the success of the business model. However, those definitions or approaches cannot be directly utilized to analyze the booming Software Defined Networking industry, because either some of the models are too complex for the non-technical manager to use, or some of the definitions are just out of date. Nonetheless, on one hand, as stated by Chesbrough and Rosenbloom (2002), albeit business model unlocks latent value from technology, the business logic constrains the subsequent investigations for new, alternative models for other technologies. Since most business models are statically depicting the business strategy of a company, it is hard to catch up with the pace of a growing technology (e.g., Software Defined Networking). On the other hand, there is a desperate need in the market, companies are struggling to choose the best-match SDN provider to upgrade their latent networks. In turn, network vendors (new entrants) are hesitating on what SDN strategy to follow. Additionally, there is little research has been done to solve those problems, which remains a barrier for companies to better design and develop new business models in an innovative IT market. Stated by Osterwalder (2004), the rapidly changing, competitive and uncertain economic environment makes business decisions difficult and challenging. Surprisingly, the business

model or software tools that can be utilized for strategic decision making are still scarce. Johnson, Christensen and Kagermann (2008) also claimed that many companies found business model innovation difficult, managers do not understand their existing business models, so they are unable to create an effective and efficient new business model. Accordingly, we conclude our problem statement as follows:
"When entering a new innovative IT market, it is extremely challenging for companies to design and develop new business models."

This thesis is intended to fill these gaps by investigating some existing mainstream SDN providers in the market via the method of using Business Model Canvas and will further propose an improved business model in a case study.

1.4 Research question

Based on the problem statement above, the authors constructed the main research question as:
"How can new market entrants best design and develop new business models in an innovative IT market?"

To better explore and validate the main research question, two sub-research questions were proposed as follows:

1. What is the suitable method to help market entrants create business models?

2. How to build up the relation between the business model and the innovative IT market?

All the research questions listed above will be addressed and answered by the deliverables of this research in the following Chapters (Table 2-1). It provided an in – depth analysis of existing SDN providers to ease the selection process for companies to choose the SDN services. An SDN strategy/vision will be provided, which aims to be the compass in the emerging SDN market for newcomers and challengers.

1.5 Scientific relevance

In this section, the scientific relevance of this research will be briefly discussed, namely the scientific contributions as well as the practical values. Detailed information about the contributions and the deliverables of this paper can be found in the Discussion (Chapter 8).

Scientific contribution
The scientific field of SDN is relatively new. Date back to 2010, the Clean Slate Program created by Stanford University symbolized a successful start for SDN. However, studies in this field are not complete. Also, there is little scientific research has ever taken SDN as a business concept and analyze it from a business perspective. The contributions of this study bring forward an approach to analyze the SDN from a business perspective and connect the business concept with the SDN technical concept, i.e., the SDN functions and features. In addition, this research validated the usability of the business model canvas in the case of SDN, which further proves that a modular business model is effective when analyzing an innovative IT market.

Practical value

Emphasizing on the scientific contributions and practical values, this thesis creates a new approach to help companies and organizations build their visions and business models for innovative IT markets. The dictionary of SDN business model canvas and SDN features can be reused and improved in the future when applied to a real SDN strategy. Furthermore, the SDN quality model, which was generated based on the business model canvas can be utilized by the end customers as an indication to choose the suitable SDN providers in the future.

1.6 Thesis outline

Following the chapters listed below (Table 1-1), this paper will discuss the research approach, theoretical background, modeling processes, comparison processes, evaluation process and display all the deliverables and results of this thesis.

Table 1-1. Thesis content overview

Chapter	Content
Chapter 2. Research approach	The research method that is applied in this thesis, which includes research model, method validation, the linkage of research questions and research deliverables, and finally the design principle.
Chapter 3. Theoretical background	A general introduction to the fields of business model, software defined networking and the bridging item we choose, i.e., the quality attributes (QA), as well as the reasons we use QA.
Chapter 4. SDN organization selection	A practical way of selecting SDN organizations in the current SDN market.
Chapter 5. SDN business model canvas modeling	The selected organizations will be modeled by utilizing business model canvas (BMC), which is introduced in the theoretical background of business models in Section 3.
Chapter 6. Unifying SDN business model and SDN architecture	This chapter introduces how we connect the SDN business model to its architecture. An SDN quality model and an SDN solution model were proposed.
Chapter 7. SDN case: Huawei Agile Network Solution	A co-creation process with the case company to develop a customized business model canvas based on the existing models we have created in Section 5 and Section 6. Then an evaluation was done for the created BMC.
Chapter 8. Discussion	Final results of the thesis, deliverables, its contributions and limitations.
Chapter 9. Conclusion	Research summary, recommendations for the future work.
Reference	Cited scientific literature.
Appendix	Some of the large tables, figures and expert review information that is not suitable to be placed in the main body of the thesis.

Chapter 2 Research approach

In this chapter, it introduces the research approach of this thesis. The research is segmented into the research model (Section 2.1), method validation (Section 2.2) and the activities linked to the sub research-questions (Section 2.3).

2.1 Research models

The research model consists of four main activities, include:

1. An in-depth literature study on the preliminary researches on the topic of business model, Software Defined Network, Business Model Canvas and quality attribute as a theoretical background to depict and support this study.
2. Modeling the existing SDN providers in the market via the Business Model Canvas.
3. Based on the prior studies, from the perspective of network vendors, this thesis has created a new business model for SDN solution.
4. Further analysis and evaluation of the business model

To further elaborate the approaches, those four activities was broken down into the following sub-activities:

1. **Constructing a theoretical background (Chapter 3)**

a. Systematic literature review on the business model and business model canvas: It will provide a thorough background of the business model and elaborate explicitly on the method of Business Model Canvas.
b. Systematic literature review on Software Defined Network: Study literature on SDN concept to explain what SDN is and their functions. This study will focus on the strategic level, thus, it will not dig into the very technical field of SDN.
c. Systematic literature review on quality attribute: It described the definition of quality attribute, and the relation between quality attribute and business models.

2. **Modeling the existing SDN providers (Chapter 4 - 6)**

a. Choose 4 SDN organizations in the SDN market, including open source provider, software oriented vendors, and software & hardware oriented vendors.
b. Model the chosen vendors' SDN solution through BMC method.
c. Based on 1-b, 1-c, construct a SDN quality model (Figure 6-1) to illustrate the relation between the SDN architecture and SDN features.
d. Create a unified SDN solution model (Figure 6-2) example to spotlight the relations between business model canvas (2-b), SDN quality model (2-c) and the SDN architecture.
e. Validate the models with companies, and revise the model.

3. **Creating a new business model for SDN case company (Chapter 7)**

a. Create an SDN BMC dictionary and an SDN feature dictionary.
b. Utilize the assembly-based situational method engineering approach to building a customized BMC for the case company.

4. **Evaluation of the model (Chapter 7)**

a. Consult a business model canvas expert to evaluate the general research approach.
b. Perform expert interviews in the case company to assess the new BMC created in step three.

According to the study did by Cohen and Levinthal (1990), the ability of a firm to realize the benefits of new, external knowledge, assimilate it, and apply it to commercial ends is essential to its capabilities. Such capabilities are the absorptive capacity of the firm, which was suggested by the authors that it was a function of the company's level of prior pertinent knowledge. In other words, analyzing the current knowledge in a market is considered as an effective way to maintain innovative. Therefore, by following that sense, the authors decided to investigate the existing SDN providers, model their current SDN business models and compare the models to design and develop new business models in the SDN market (Chapter 5). Based on the consensus of analyzing prior knowledge and existing SDN providers, method engineering will be applied to create the methods of developing new business models. Khadka, Reijnders, Saeidi, Jansen and Hage (2011) have proved that assembly-based situational method engineering from Brinkkemper, Saeki and Harmsen (1999) and van de Weerd and Brinkkemper (2008) is appropriate and effective as a way to reuse data to construct new models. Therefore, the BMC co-creation process was proposed in the following section.

2.1.1 BMC co-creation process

The BMC co-creation process is not a stand-alone activity. To eschew bias opinions, the authors have conducted a co-creation session with the SDN manager in the case company in a virtual environment.

In the follows sections, we will introduce each step of the co-creation process to provide a holistic view on how did we conduct the research. The co-creation process contains seven steps, and is based on the assembly-based method engineering (van de Weerd, Brinkkemper, Nieuwenhuis, Versendaal & Bijsma, 2006) and (Ralyté, Deneckère & Rolland, 2003). Step 7 was illustrated in dashed lines, because it was not evaluated within the case company but as an additional proposition for the case company and future researches.

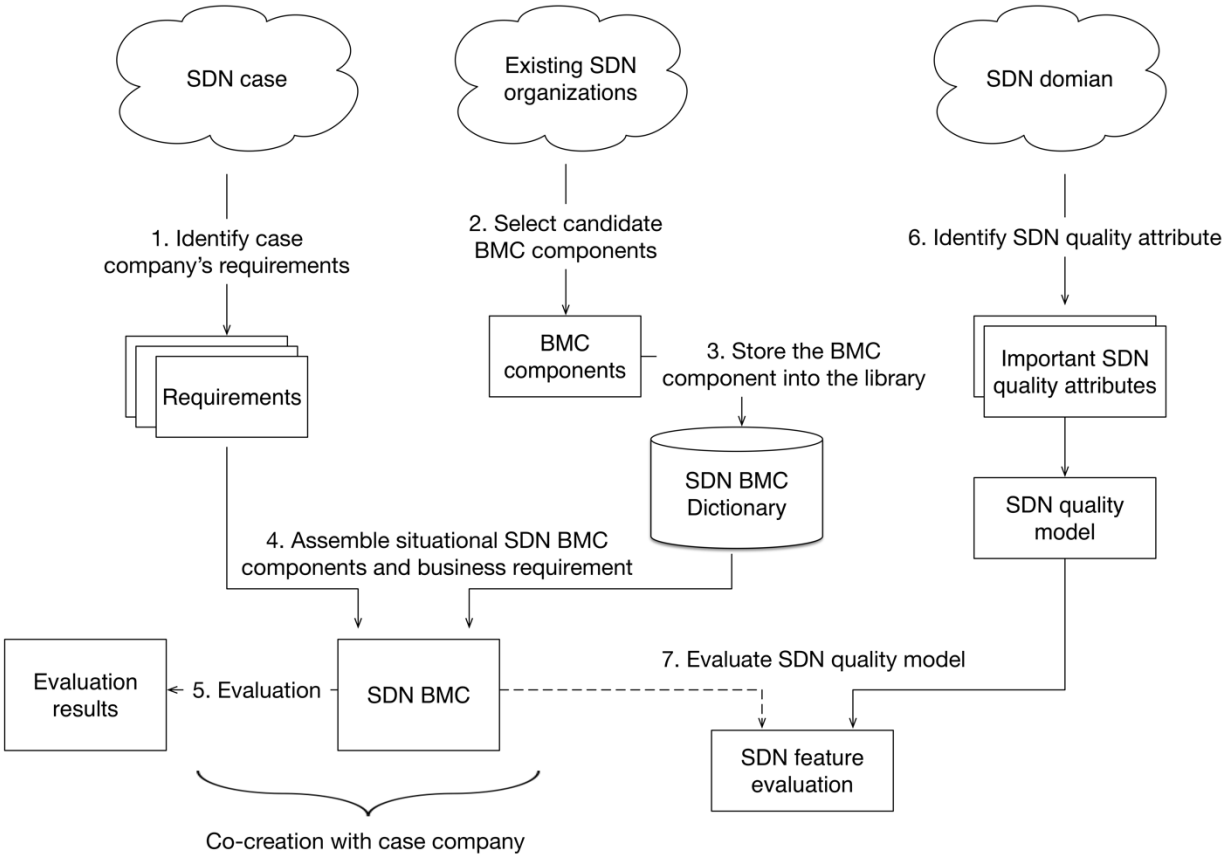

Figure 2-1. BMC creation process

1) Identify project requirement. In this step, the authors have worked closely with the experts from the case company to understand and co-create the best-fit BMC for them. It will be elaborated further in the mining process below.
2) Select candidate BMC components. BMC components were collected from four BMCs of the selected organization, which will be presented in Chapter 5.
3) Store the BMC components into the dictionary. This step extracted all the BMC components from each BMC and stored them in one database (Appendix D).
4) Assemble situational SDN BMC components and business requirements. In this step, the authors have created a business model canvas based on the requirements gathered in step 1, then by referencing the SDN BMC dictionary, the author provided complement BMC components to complete the SDN BMC of the case company.
5) Evaluation. The authors have conducted several expert reviews of the SDN BMC to evaluate the model. Besides, a SWOT evaluation form was sent to the case company for further validation.
6) Identify SDN quality attribute. In this step, the author reviewed the existing relevant studies and papers to identify the critical quality attributes. The SDN quality model is based on ISO 25010, which is the quality model for software quality.
7) Evaluate SDN quality model. Although, the initial design was to make the case company validate their SDN features with the SDN quality model, which could help them identify their SDN capabilities. In this thesis, the author was not able to validate the SDN quality model in the case company, but the SDN quality model was reviewed in the expert

interviews with the four selected organizations. This step will be further elaborated in the SDN feature mining process (Figure 2-2).

2.1.2 SDN feature mining process

To extend the usability of BMC for the case company, the authors proposed an SDN feature mining process, which aims to find the best-fit SDN features for the company. However, as mentioned above, this process was not able to be evaluated in our case company due to the thesis scope which focused on creating new business models. Hence, this feature mining process was proposed for feature studies.

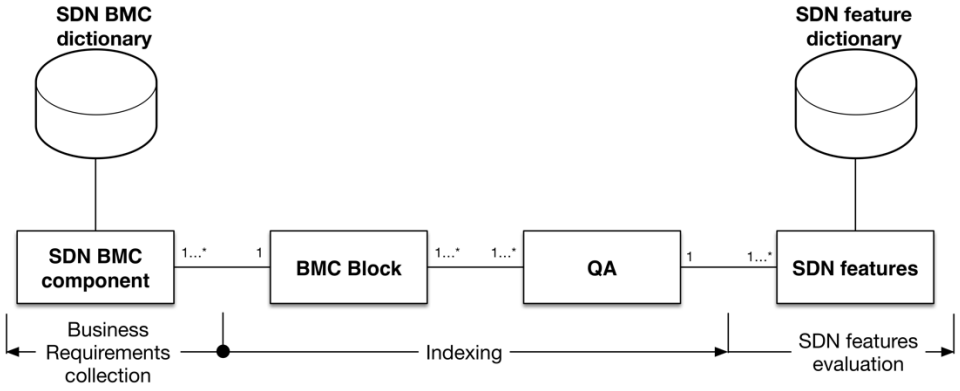

Figure 2-2. BMC component and SDN features mining process

The SDN feature mining process contains three mains steps, which are 1) business requirement collection, 2) Indexing and 3) SDN feature evaluation. It shows that business requirement collection goes in a different direction than the other two steps, because the SDN BMC components will not influence the BMC blocks, nor the SDN features. Only in some specific business cases when the required BMC components only represent several but not all BMC blocks, then SDN BMC components will influence the SDN features. In the mining process of this thesis, we can only index the BMC blocks of value proposition and customer segment to the QAs and SDN features that have been identified.

1. Business requirement collection

It is crucial to understand and identify the uses or purposes of the models when undertaking modeling of any kind (Aguilar-Saven, 2004). In other words, without knowing the proper business cases and requirements, it is hard to discover the best-designed business model, neither with the "must-have" SDN features in our research. For example, there are three main use cases in SDN business, Datacenter, Enterprise, and campus. Different use cases require different technologies and solutions. There's no generic model that can cover all the situations in the market, neither our research can not exclusively list all the SDN features and SDN BMC components to spin all the use cases. Therefore, business requirements collection phase is critical to ensure the quality of the chosen SDN BMC components. According to the BMC components, the authors can help and select the best-suit SDN BMC components from our SDN BMC Dictionary.

There are many methods and approaches exist on the market for gathering business requirements, each method has its own advantages and disadvantages but always has the limitation of only explaining a certain view of enterprise (Shen, Wall, Xaremba, Chen & Browne, 2004). In this research, the authors use the approach suggested by Osterwalder and

Pigneur (2010) to capture the business requirements by using business model canvas and some brainstorming with our case company. The tool can be found on https://canvanizer.com; it is a website based tool for brainstorming and business model building.

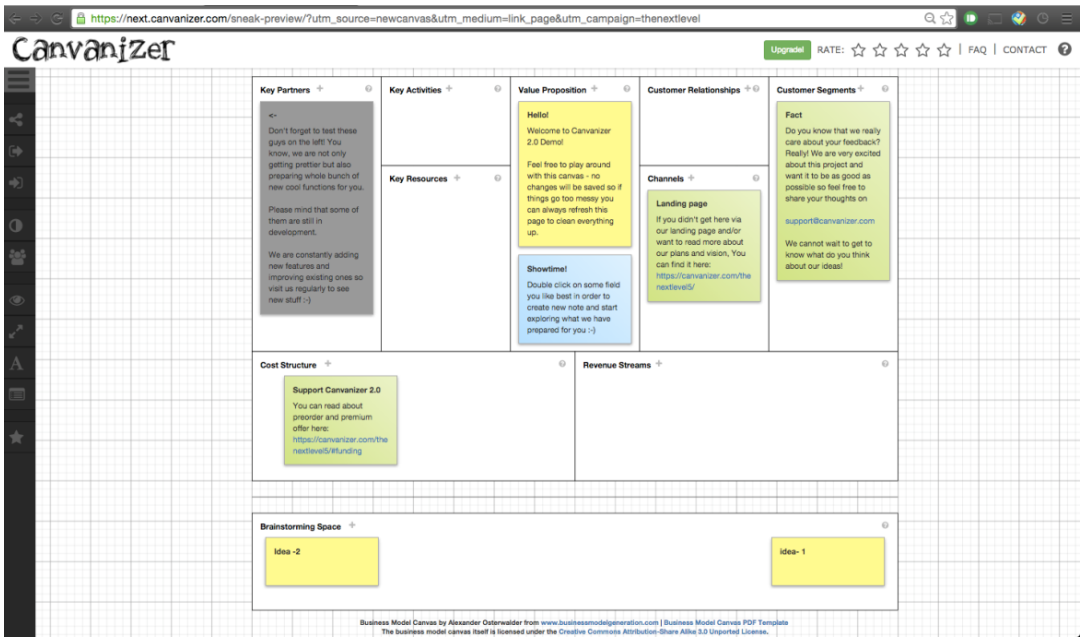

Figure 2-3. Screenshot of the business model canvas web-based too

2. Indexing

The second step is to follow the right path based on the SDN quality model in Section 6, and figure out what are the most significant SDN features needed from the SDN feature dictionary. To illustrate this process, the authors created an example to explain the indexing process (Figure 2-4).

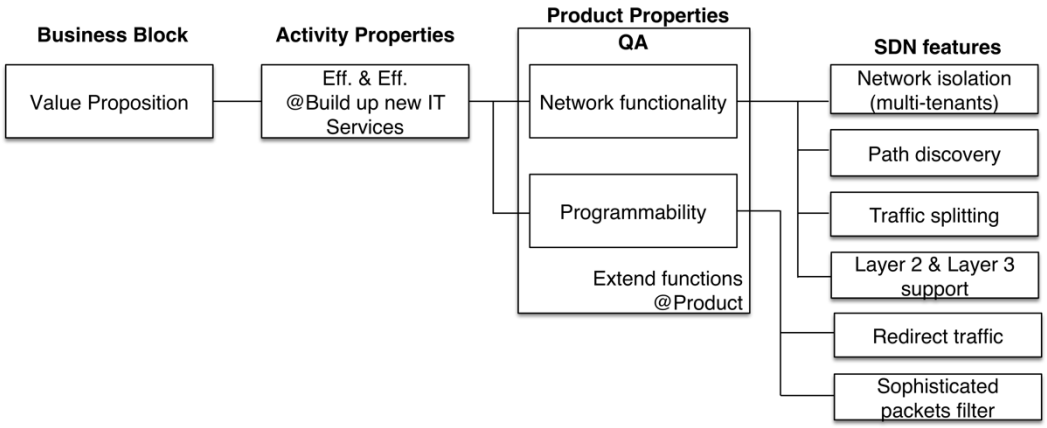

Figure 2-4. Indexing example

According to the SDN quality model (Figure 6-1), for instance, a company has owned a mature business model, the only thing they want to investigate and update is their value proposition block in the business model canvas. So they can only analyze the [Value Proposition] in the BMC block, the following path is suggested: In the business block column, one of the activities

that links to value proposition is Eff. & Eff. @Build up new IT Services, which connects to two main quality attributes in Product Properties, Network functionality and programmability. After determined the quality attributes, one can map it to the SDN features in the SDN quality model. In this example, network functionality is connected to network isolation, path discovery, traffic splitting and Layer 2 & Layer 3 support. Besides, programmability is linked to redirect traffic and sophisticated packets filter. Accordingly, these are the SDN features that may play essential roles to achieve the business segment [Value Proposition] in the SDN business model canvas. Note that the example provided above may lack quality attributes or SDN features in real business cases, thus, the model should be treated as a module based tool to apply in a situational way.

3. SDN feature evaluation

After locating the potential SDN features for all the business blocks, the next step is to evaluate the SDN features with some networking engineers to finalize those technical jargons with our capacity. In other words, SDN providers can compare their owned technologies, and those SDN features (functions) to check what is missing, and what has been adopted (Figure2-5).

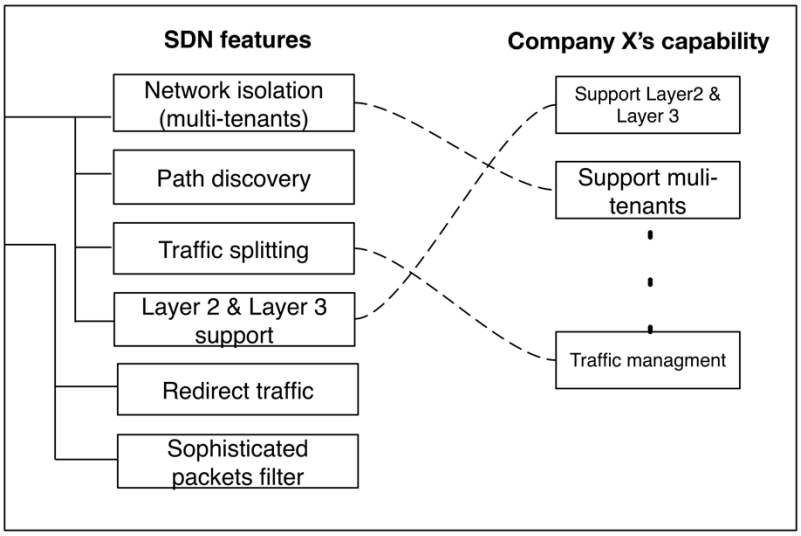

Figure 2-5. SDN features evaluation example

The evaluation process used the SDN quality model (Figure 2-6) by adding another column for company X, and checked whether the the company X had adopted certain SDN features or not. In the example of Figure 2-5, company X has adopted three SDN features, Layer 2 & 3 support, Network isolation and Traffic splitting. However, it is obviously that company X does not have path discovery, traffic redirection or sophisticated packets filter. Furthermore, after the quick mapping, the SDN provider could use the SDN solution model to map those SDN features with specific SDN application/services in the SDN architecture, which will be further elaborated in the next section.

2.1.3 Unifying SDN business model and SDN architecture

In this section, the authors created an SDN solution model by linking the SDN business model canvas and SDN architecture via an SDN quality model. Prior to the model creation, several key quality attributes will be identified in this section. The SDN solution model will provide a

mechanism to enable the user to target the essential SDN features based on their business requirements.

Based on the SDN architecture, the authors analyzed the SDN features in three different categories-application plane, controller management plane and network device (Haleplidis, et al., 2014). The most important category is the controller/ management plane according to Metzler, Metzler and Associates (2013), and they proposed ten prominent features an SDN controller should contain. Based on that, the authors proposed fifteen quality attributes (QA) that best reflect those features for an SDN controller (Table 2-6). Those features are:

Table 2-1. SDN quality attributes list

Quality attributes	Description
Supportability	Supporting OpenFlow as the southbound interface
Network Functionality	Network isolation, centrally and automatically configuration, path discovery, and so forth.
Programmability	SDN enables a programmatic interface to the controller.
Reliability	Solutions to mitigate the the failure of the SDN controller.
Visibility	The controller needs to have end-to-end network visibility
Virtualizationbility	Tenant-specific virtual networks that is decoupled from the topology from the physical network
Scalability	Mitigate broadcast overhead and proliferation of flow table entries.
Performance	flow setup time and number of flows per second an SDN controller can set up.
Security	Supporting enterprise-class authentication, having the ability to filter the packet in any sophisticated way and completely isolates the tenants in the sharing network
Vendor capability	Technical competence, financial ability.
Extendibility	Supporting various of northbound interface for building applications
Application ecosystem	Third party application support, continuous application spanning environment, e.g., AppStore
Application controllability	Each application should be granted a limited control and visibility of the network depend on the functionality of the application
Physical device support	Whether the SDN provider offers physical network device, e.g., Router, switch.
Virtual device support	Whether the SDN provider offers virtual network device, e.g., vSwitch

Supportability

Supportability in this thesis means the support for OpenFlow standard. OpenFlow is a southbound interface that connects the controller plane and the forwarding plane. It is one of the most popular southbound API in today's SDN market. Open Network Foundation, a user-led organization, dedicated to promotion and adoption of SDN, and manages the OpenFlow standard. It has over 150 members, and most of them support OpenFlow protocol. For example, Cisco, Dell, HP, NEC and many other large network vendors in the market. Therefore, it is believed that the volume of OpenFlow-enabled switches and OpenFlow-supported SDN controller will become the mainstream shortly. Hence, to evaluate the quality or capability of an SDN controller, the authors decided to subsume the supportability of OpenFlow protocol as one of the essential QAs of the SDN controller. The supportability can also refer to support other southbound interfaces in the future.

Network Functionality

Functionality is a very broad term, but in the QA list of SDN controller, it means the functionality of isolating the networks from one another, and at the same time, to be configured centrally and automatically. It is also essential that the SDN controller can make routing decisions not based on a fixed algorithm but depends on multiple header fields. Besides network isolation, path discovery and traffic splitting functions are also very crucial functions that an SDN controller should contain. These capabilities eliminate the limitations of the spanning tree protocol and improve the scalability and performance of the solution. Furthermore, SDN controller should have the functions to support various sets of constructs that enable the creation of Layer 2 and Layer 3 networks in a tenant-specific virtual network (Metzler, Metzler & Associates, 2013).

Programmability
Comparing to the device by device basis configuration techniques in the conventional networking environment, SDN enables a programmatic interface to the controller. It not only solves the time-consuming, error prone and inconsistent barriers of the traditional controller, but also enriches the functionality of the network. In other words, the users can develop whatever network applications to extend the functions of their networks. Some significant programmability examples could be redirecting traffic and applying sophisticated filters to packets. Moreover, by implementing a northbound API, the programmability can be enhanced by adding three party applications. Those applications could be some traditional network services such as load balancers and firewall or an orchestration system like OpenStack.

Reliability
Although the programmability solves the problems of the traditional device by device configuration process, which eliminates manual errors and, therefore, increases network reliability. However, the SDN controller will become a single failure point that may decrease the reliability of the entire network. As a consequence, to counter that problem becomes one of the important points for organizations. On one hand, the solution could be that the SDN controller provides a multiple paths discovery technique, which can set up multiple paths between the origin and the destination. In this case, the availability of the network does not depend on a single link. On the other hand, the controller could set up only a single path, but can reactive for the traffic change under a continuous network topology monitoring basis. Metzler, Metzler and Associates (2013) also mentioned that supporting other technologies and design alternatives, e.g., Virtual Router Redundancy Protocol (VRRP) and Multi-chassis Link Aggregation Group (MC - LAC) can improve the reliability of the network.

For the controller itself, it is important that more than one controller will be deployed in the network. They can follow a clustering solution, which means the users deploy several SDN controllers in the network and set them into active or standby mode. If one controller fails, the standby controller can continue to work. However, it is difficult to transfer from the failed controller immediately to the standby controller, so companies should be aware whether the SDN controller support such synchronizations.

Visibility
In a traditional network environment, the service provider (e.g., network vendor AT&T) they do not know whether it emerges a failure in one of their end users. They may monitor a network in

an area, but it is impossible for them to see the end-to-end network flows. Therefore, unless there is a major failure in the network or the users inform them personally, the service provider will not be aware of the problems. One of the instances of a traditional network monitoring techniques is sFlow[12]. Hence, a good SDN controller must be able to have the ability to have the end-to-end network visibility. For example, an SDN controller can use OpenFlow to identify problems in the network and change the path of the flow. Additionally, to eliminate the workload of an SDN controller, it must contain the function to choose what scope of the network the controller should monitor. Hence, it will not waste any power to monitor other irrelevant networks.

Virtualizationbility

Network virtualization is one of the most important benefits of SDN. However, unlike SDN, network virtualization is not new at all. There are two types of network virtualizations that have been in productive networks for decades. One of them is virtual LAN (VLAN), it enables the Ethernet network into at most 4094 broadcast domains and eases the way to isolate the different type of traffic that share the same infrastructure. The other virtual network is Virtual Routing and Forwarding (VRF), it is a form of Layer 3 network virtualization that enables a physical router to support multiple virtual routers. Those virtualization approaches are helpful, however, according to Metzler, Metzler and Associates (2013), their limitations both lie in scope and value. They stated that the network virtualization must be end to end and abstract the network in the likewise way that server virtualization does, which aims to create a tenant-specific virtual networks that is decoupled from the topology from the physical network. The advantages of decoupling the virtual networks from the physical networks are that it enables the flexibility to allow the organizations to change their physical networks infrastructures. In other words, SDN network virtualization makes it possible for organizations to use whatever hardware they want. In this case, it not only expands the choices for organizations to choose a better hardware provider but also makes it possible for them to migrate smoothly from the traditional network structure to SDN. Therefore, the authors subsume "virtualizationbility" as one of the QAs for SDN controller.

Scalability

Organizations that are evaluating the SDN product need to consider the fact that network broadcast overhead will decrease the scalability of the solutions they implement. As a result, the users should ensure that the SDN controller can mitigate the impact of network broadcast overhead. Another reason that will cause the scalability issue is the proliferation of flow table entries, because a hop by hop entry is required for each flow if there is no solution for optimization. One solution, according to Metzler, Metzler and Associates (2013), is to make SDN controller use header rewrites in the core of the network. In this case, the unique table entry exists at the ingress and egress of the network. Furthermore, being able to span multiple sites is considered as another aspect of scalability of SDN controller. This capability allows the controller to move the virtual machines (VMs) and virtual storage between sites, which means the SDN controller should be enabled on automatic routing and forwarding to the migrated servers and storage.

Performance

[12] http://www.sflow.org

In functionality, the authors mentioned about the essential features of establishing flows for SDN controller. To estimate how SDN controller performs this function, Metzler, Metzler and Associates (2013) proposed two key performance metrics: flow setup time and number of flows per second an SDN controller can set up. Based on the metrics, an organization could tell whether they need additional SDN controllers or not. Considering the flow setup time, there are two ways: proactive or reactive. Proactive flow setup technique pre-sets the OpenFlow switch to know what to do when the first packet comes. It is a very ideally situation that the SDN controller pre-populate the flow tables to the maximum degree. Reactive flow setup, in contrast, the switch does not know what to do with the packet. Instead, the OpenFlow switch will send it to the SDN controller, and the controller will decide how to process the flow and how long to keep the cache alive for that packet. Therefore, the time consumption consists of the time it costs to send the packet from the OpenFlow switch to the SDN controller, the processing time in the SDN controller and the time it takes to send the packets from the SDN controller to the switch. As stated by Metzler, Metzler and Associate (2013), the key factors influence the setup time are the processing power of the switch and the I/O performance of the controller. I/O performance is affected by some factors such as the written programming language of the controller (e.g., the I/O performance of the controller is better if it is written in C instead of Java).

Security

Security is within the functionalities, but due to the importance of network security, it will be mentioned it again separately. Making available a security network, the SDN controller should support enterprise-class authentication, which means that the controller should be able to authorize different levels of access for various employees in an enterprise scale. Moreover, the SDN controller should be in a position to let the network administrator to turn down the access to control traffic. Making sure the SDN controller has the ability to filter the packets in any sophisticated way and completely isolates the tenants in the sharing network. Furthermore, having the capacity to detect attacks and alert the network administrator is considered as an important function as well.

Vendor capability

Last but not least, to choose an SDN controller is not one-day decision. Once an organization has chosen a company's SDN controller, it has to follow many rules and probably some restrictions on using the SDN controller. Therefore, it becomes a long term strategy. It is important to determine the technical competence of the vendor. For example, checking whether the network vendor has a world-class engineer team, or a number of certificated network engineers. Another key factor is the financial ability of the vendor. It is suggested to check how much money they will invest in the R&D of the SDN field, what is the future financial situation of the company. Since SDN is a fast changing technique, if there's no continuous financial support, the company will not be able to keep up with the rapidly changing pace of the SDN environment. Moreover, customers should be cautious with the young SDN startups because they might be technically successful at the moment, but there is a high risk they will have a huge organization impact in the future. For instance, if another company acquires this startup, many of their services and support will be affected, so does their services and supports to your company. The authors use three main criteria to evaluate the vendor capability, 1) the financial status, which is assessed by using Standard & Poor's short-term financial rankings. 2) technology, which is based on PwC Global 100 Software Leaders Report (PwC Global 100 software leaders, 2014). 3) sustainable

development, which refers to the long-term financial ranking from Standard & Poor's. The authors cannot find VMware's financial rating in Standard & Pool, and OpenDaylight is an open source organization. Hence, there is no financial and sustainable for VMware and OpenDaylight. In addition, because OpenDaylight is a relatively new organization, the authors could not find its technology capacity report. Cisco and HP's short-term and long-term rating can be found in the table below (Table 2-1 and Table 2-2). Further information about the rating definitions can be found on the website in the references.

Table 2-2. Standard & Poor's credit rating of Cisco System Inc. (Cisco System Inc. Credit Rating, 2013)

Rating Type	Rating	Rating Date	Outlook
Local Currency LT	AA-	16-Dec-2013	Stable
Local Currency ST	A-1+	31-Jan-2011	
Foreign Currency	AA-	16-Dec-2013	Stable
Foreign Currency	A-1+	31-Jan-2011	

Table 2-3. Standard & Poor's credit rating of HP enterprise (Hewlett Packard Enterprise Co. Credit Rating, 2015)

Rating Type	Rating	Rating Date	Outlook
Local Currency LT	BBB	24-Sep-2015	Stable
Local Currency ST	A-2	23-Sep-2015	
Foreign Currency	BBB	23-Sep-2015	Stable
Foreign Currency	A-2	23-Sep-2015	

Similar to the SDN controller plane, several QAs were discovered to delineate the features in the application plane as follows:

Extendibility

One of the main advantages of SDN is the extensibility for countless innovations of new network applications. Applications are developed to manage network traffics, securities and the efficient of using energy (Scott-Hayward, Kane & Sezer, 2014). By applying an open northbound API, an SDN provider is able to give accessibility to all the developers to use their SDN controller software. It is a very basic function that an SDN product should have, so when assessing an SDN product, one must take the extendibility into consideration.

Application ecosystem

On the one hand, a company should evaluate whether the SDN provider supports external applications and orchestration platform. On the other side, it is also crucial that the SDN provider has its application ecosystem, which provides a continuous spinning environment for SDN. It usually refers to an application market or likewise to the AppsStore in the mobile phone market. An SDN AppStore or equivalent platform not only provide a place for SDN user to download the applications, but also offer a channel for developers to sell their SDN software. According to Osterwalder and Pigneur (2010) 's book, they define this pattern as a multi-sided platform. A multi-sided platform grows in value by facilitating interactions between different groups, and

one group exists only when the other groups are also present. Hence, it automatically increases the customers size and help the SDN provider maintain more than one customer segment.

Considering the sustainability of an SDN product, customers may take whether this SDN provider has multi-sided platform for its SDN product as one of the essential criteria.

Application controllability

Northbound interface connects the application plane and the SDN controller. This interface is in charge of controlling trusted applications to program the network, and solicit service or information from the network (Scott-Hayward, Kane & Sezer, 2014). The interaction can be concluded as reading the network state and writing network policies. Reading network state depicts the application sending an HTTP GET request to the controller, and the controller communicates the request to the relevant data plane after interpretation. After receiving the requested data from the data plane, the controller interprets and provides it to the application in an HTTP response. Writing network policies is likewise to reading network state, instead, sending the HTTP GET request, the application sends an HTTP POST request to the controller, and the controller interprets and converts the request into a particular Southbound command instruction to modify the relevant switch to update its flow table. The controller then sends back an HTTP response to the application to inform the status (success or failure) of the new rule installation result. Scott-Hayward, Kane and Sezer (2014) claim several weaknesses in this approach:

- No authentication of the RESTful API or other northbound API.
- No scheme to guarantee that there is no overlap or interfere with one another in the rules installations.
- Applications are not required to provide identity information.
- No application regulation or behavior inspection after installation.

Nowadays many SDN providers use RESTful API as their northbound interface, which reveals a potential risk of application malware attack. Therefore, to assess whether it is good SDN product, a company must check if the application plane, the northbound API, and the SDN controller have an application control feature. In other words, each application should be granted a limited control and visibility of the network depend on the functionality of the application.

Network Device

The third part in the SDN architecture is the network device. On the one side, obviously, that VMware and OpenDaylight they do not have their physical device since their main products are their network virtualization/SDN softwares. On the other side, Cisco and HP are active both in software and hardware.

So far, the authors have collected the data from both companies' website and documents. For examples, Cisco has its Nexus serious physical switches that support SDN and its application-centric infrastructure. HP has its OpenFlow switch such as 12900 and 12500 switch series, check the website[13] to find more about the HP's SDN switch portfolio. However, in this research, the

[13] http://h17007.www1.hp.com/nl/en/networking/solutions/technology/sdn/portfolio.aspx#.VktWzM7m-7M

authors will not dive into the physical or virtual network device to understand their features and difference. Thus, in the network device part of the SDN quality model, the quality attributes only contain two elements, the physical device and the virtual device.

SDN quality model

In regard to the quality attributes introduced above, the authors expend each X–bility into several sub-SDN features. Those SDN features references to the paper of Metzler, Metzler and Associates (2013) and Scott-Hayward et al (2014). The SDN features they proposed were comparatively important, but cannot cover all the functions for SDN. The authors extended these SDN functions into fifteen quality attributes, and map those quality attributes with the three SDN layers (Figure 2-7). Some of the quality attributes are from the ISO quality model (ISO 25010), such as reliability, security, performance, but many of the quality attributes are specifically related to SDN. Despite the importance of vendor capability, and its crucial role in the SDN eco-system, it was excluded from this SDN quality model, due to the fact that, this attribute is seemingly less relevant from the software development perspective.

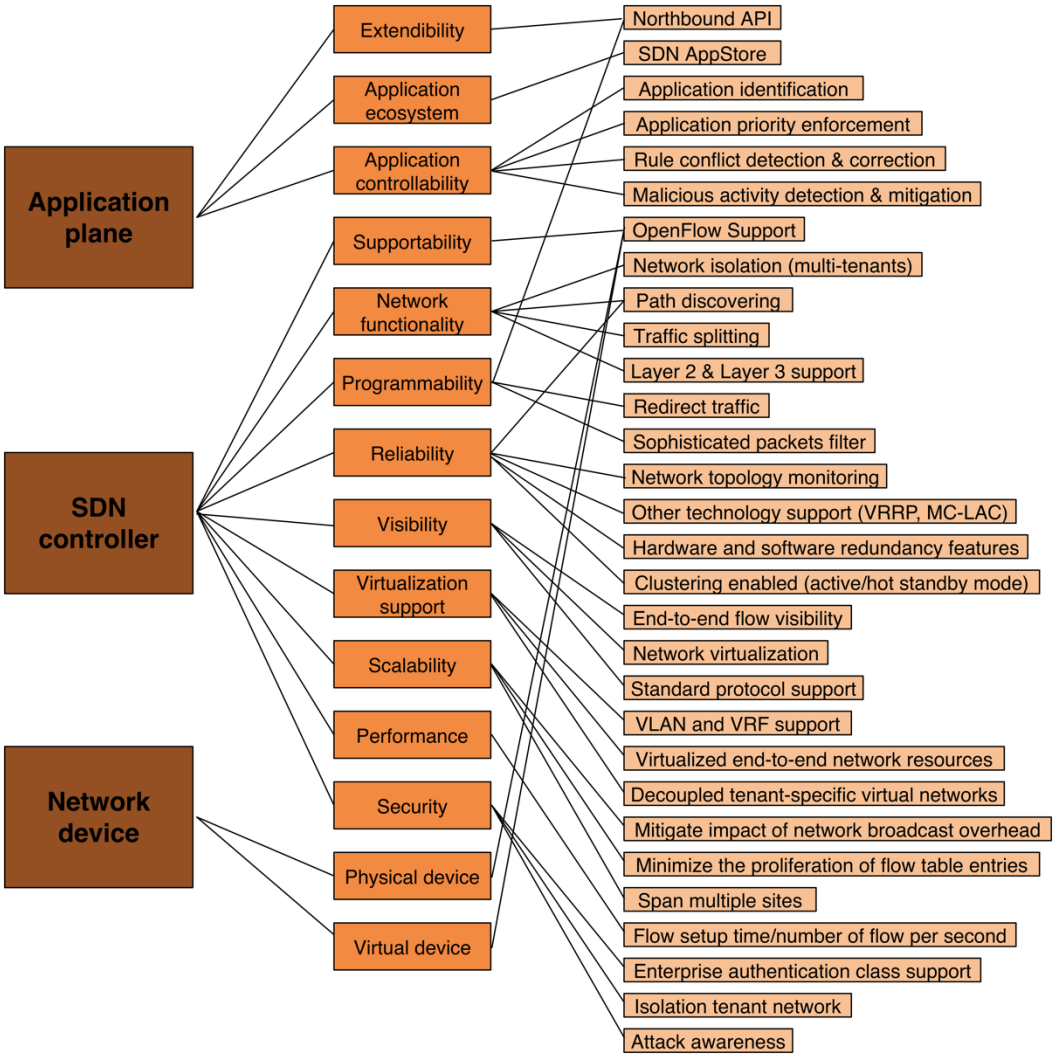

Figure 2-6. SDN features evaluation example

SDN solution model

To better illustrate the relation between the business model canvas and the SDN architecture, the authors proposed an SDN solution model (Figure 2-7). The SDN solution model contains three parts (from high/left level to low/right level); level 1 is the business model canvas and the value proposition canvas, level 2 stands the unified quality model from Lochmann and Goeb (2011) and level 3 displays the SDN architecture. The idea of the SDN solution model is inspired by the enterprise meta-framework described by Sowa and Zachman (1992) and the feature model proposed by Riebisch (2013). Although they studied on different objects, they utilized the same concept, which is to create a meta-level model, and then zoom in, connect the meta-level model into a more concrete and practical level. Moreover, the SDN solution model relies more on the unified model for software quality, proposed by Lochmann and Goeb (2011). They divided their quality model into several different properties, e.g. product property, environment property, activity property. Beside, they added inspections, code analysis and measurement into the model. However, aiming to design a high-level business model and connect it with the technical architecture, some of the detailed parts, such as inspections, code analysis and measurements, were omitted.

Figure 2-7 was utilized as an example to explain the model. As an example, the lines in this example cannot represent all the relations for the SDN business model canvas. Regarding quality model is used to evaluate a software product, thus, the focus will lie on the value proposition and customer segments, which also known as the value proposition canvas[14]. Value proposition canvas is the sister modeling tool of business model canvas, but it is out of the research scope. Thus, it was utilized as an abstract concept rather than expanded it into several detailed pieces. As has explained in the previous sections, it is difficult for the business people, who locate at level 1, to understand the technical architecture, i.e., level 3. Therefore, the authors appointed a quality model, in level 2, to bridge level 1 and level 3. For example, in Figure 2-7, there is a line connect the value proposition canvas in level 1 with activity property: Eff. & Eff.@Monitor netowk in level 2, which then connects to Network Monitoring@Product via the quality attribute "visibility". Then, the product property Network Monitoring@Product bridges to the management plane in SDN architecture to indicate what kind of functionality the SDN controller should provide/adopt. Similarly, starting from the value proposition canvas in level 1, connected with the Eff. & Eff. @Build up new IT Service in the activity property, which goes to the Extend Functions@Product via both "network functionality" and "programmability" in level 2. The Extend functions@Product is then mapped with some certain applications in the application plane in SDN architecture. There is no specific applications or services have been mapped in the SDN architecture in this example, but in a practical situation, a networking engineer could map a certain application or service on the SDN architecture to present their solution to their sales/business people. Furthermore, they can present this SDN solution model to their customers to illustrate their SDN propositions. Hence, it is a modular based concept, i.e., each business model canvas component, QA and application/service can be replaced according to different situations.

Accordingly, the unified SDN solution model creates an understandable, module based, full SDN concept representation tool for both the business people and technical people. The authors believe that the solution model can ease the collaboration between the business side and the

[14] http://www.businessmodelgeneration.com/canvas/vpc

engineering side of the company. Moreover, it is a tool that can be utilized to better represent a company's SDN propositions to its potential customers.

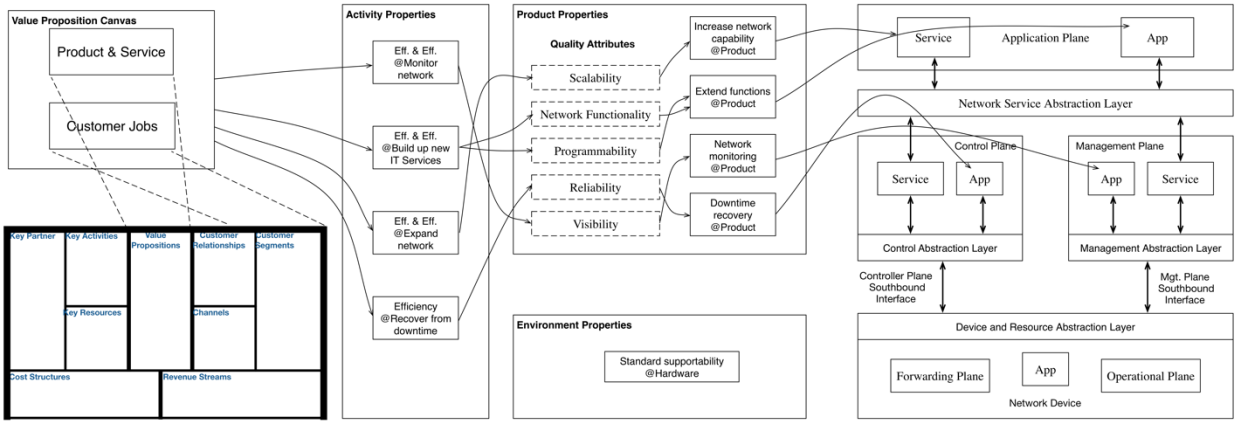

Figure 2-7. Example SDN quality model.

2.1.4 Representation of the research method

The authors utilized the process deliverable diagram (van de Weerd & Brinkkemper, 2008) to illustrate the overall research process. On the left side of the model, it depicts the meta-process model that comprises the detailed activity flow. The right side illustrates the meta-deliverable model comprised of the associated concepts linked to the origin activities. Process deliverable diagrams (PDDs) has been proven to be an effective way for the meta-modeling of methods, especially in the analysis and design phase. According to van de Weerd and Brinkkemper (2008), PDDs can serve different research purposes, and offers the capability for comparison and method adaptation. Besides, it provides an explicit description of the activities and concepts of a method in a PDD, which allows for a more formal supplement of activities and deliverables. Two tables delineate the activities and deliverables can be ascertained in Appendix B.

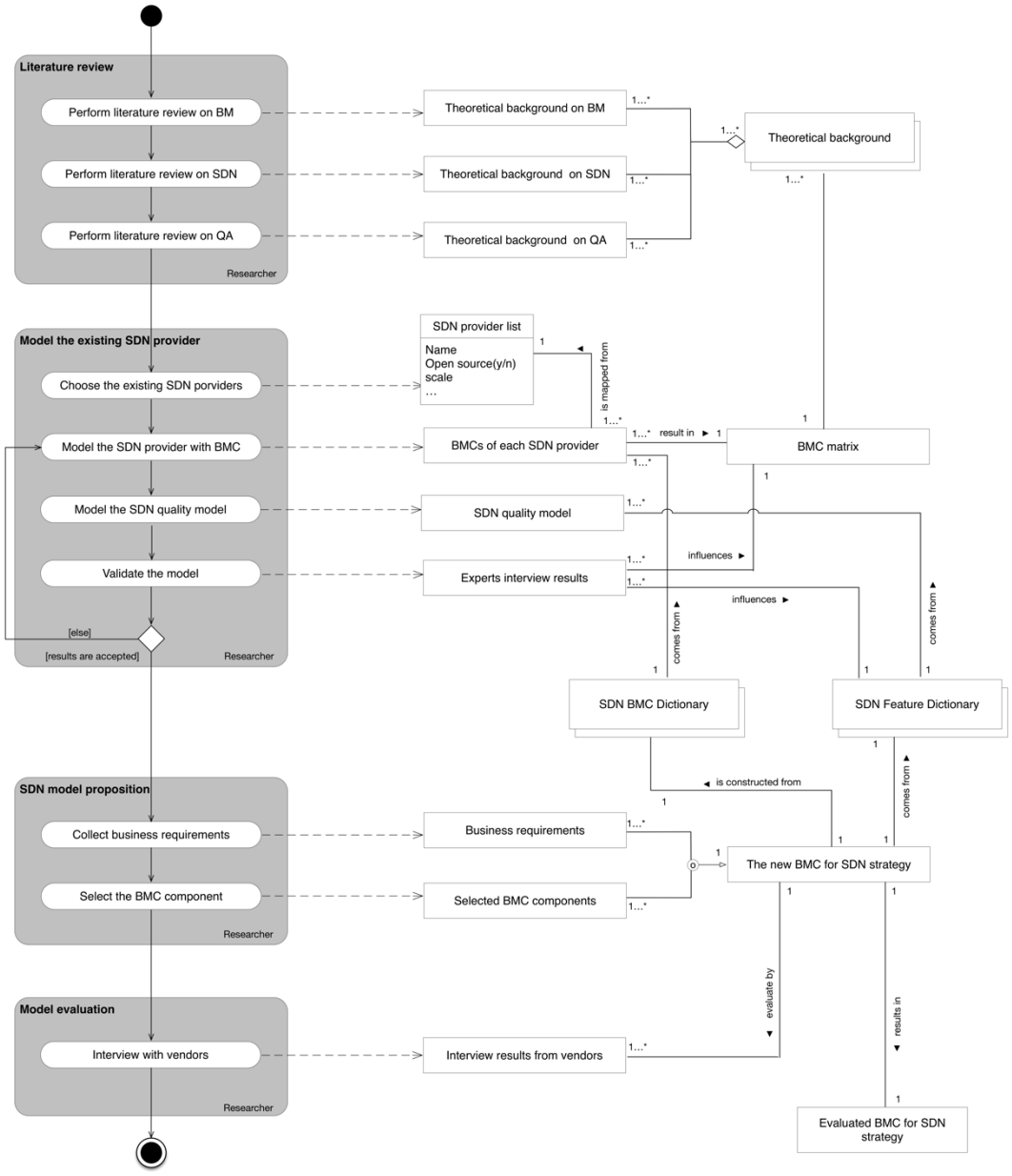

Figure 2-8. Process Deliverable Diagram (PDD) of the research approach.

2.2 Method validation

The business model canvas of each selected organization, as well as the SDN quality model, undertakes a validation of their correctness and rationale with four experts from each organization. In the semi-structured interviews, by presenting the experts with the business model canvases and the SDN quality model, the correctness, and rationale of the model were validated.

Explicitly, for the purpose of reproducibility of the research results, validity is presented in the following three aspects:

2.2.1 Internal validity

The main outcome of this research is the overall approach to design and develop business models in an innovative IT market domian. This approach is based on the research model and the existing SDN organizations. Data collection phase can be divided into three parts (Table 2-4):

Table 2-4. Source of data collection

Data type	Source	Sub-source (examples)
Organization selection data	Consultancy report	ESG market landscape (2013)
	Organizations' official websites	Organizations' partner names
Selected organizations' BMC related data	Selected organization's official websites	Business service description
		SDN product description
		Product community
		Purchasing channels
		Partnership program
		Help desk
	Publications	SDN for dummies (Cisco, 2015)
	Technical documents	Product manuals
SDN features related data	Literature	Scott-Hayward, Kane & Sezer (2014)
	Technical documents	Technical white paper (HP virtual application networks SDN controller white paper, 2015)

We need three kinds of data to fulfill this research. 1) SDN provider names. 2) Business services that relate to the BMC, 3) SDN feature data. Although, the sources from the websites may become potential threats to internal validity, it was compensated by conducting interviews with the current employees from each company. The primary goal of the interview is to validate the data/models collected for their businesses, but there are chances that biased opinions will be involved. Another major threat to the internal validity is the time given for the data collection. The research period started from June of 2014 to the January of 2016. Given that SDN is a fast growing market, the data in this thesis may have changed during those months.

2.2.2 External validity

The goal of this research is not to provide a complete model or system (with exhaustive data) that can be instantly applied to real business cases. Though SDN was utilized as a validaton choice to prove that our approach is effective and efficient, the authors firmly believe that the approach should be able to implement in any innovative IT case by switching the data/modules. The overall research approach did not rely on any single criterion, for examples, the research context is replaceable, i.e., the organization selection process can be utilized to select other companies in other industries. The BMC Dictionary content can vary depends on certain research context. For instance, the research approach can be applied to analyze how to design business model in Cloud business, then the BMC Dictionary will store Cloud related BMC components. Besides, the approach was validated by a business model canvas expert who is the coach of Strategyzer[15] and certified by the creator of the model. The business model canvas was used in

[15] https://strategyzer.com

this thesis. Potential threats to the external validity could be the number of expert reviews, and the short period of data collection, the similarity of other business cases other than SDN.

2.2.3 Reliability

The research approach used in this thesis is valid, and can be reapplied if someone else performs the same research again with the same subject. The authors follow a standard design science approach based on the book of Wieringa (2014), and all the data can be tracked down by using the link or documents provided in the reference. Considering the reality of the fast growing of the SDN market, the data in this research may not be the same if someone performs the same research after a long time afterward.

2.3 Activities linked to the sub-research questions

To better illustrate the research questions and its correspond research deliverables, a table (Table 2-2) is created below:

Table 2-5. Research questions and matched research deliverables.

Sub research question	Description	Deliverables
What is the suitable method to help market entrants create business models?	Based on Levinthal (1990), the authors decide to analyze the existing SDN provider as the research context to explore and develop new method for creating business models for market entrants. The research contexts are modeled by utilizing business model canvas, and the results are compared in a comparison matrix and validated by experts from each organization.	• SDN provider network • Main SDN market player • SDN open source organization
How to build up the relation between business model and the innovative IT market?	After the business model canvas is built for the organization, it remains hard for companies to apply the model in to their real business. Thus, the authors utilized the unified quality model to bridge the business concept and the technical architecture.	• SDN quality model • SDN feature library • SDN solution model

2.4 Design principles

Inheriting the design science methodology introduced by Wieringa (2014), the research method of this thesis follows two essential paradigms of the design methodology. The engineering circle and the research circle (Figure 2-9). Given that this paper is built up on a case study to design and develop business models in an innovative IT market, therefore, it leans more on the engineering circle by following the five high-level approaches. 1) problem investigation, 2) Treatment design, 3) Design validation, 4) Treatment implementation and 5) Implementation evaluation. However, step four and five cannot be done within the period of this research, thus, it is out of the research scope. In problem investigation, this research has analyzed the SDN market

and business model problems, the phenomena, causes, impacts have been identified in Chapter 1. Treatment design is outlined by the general research approach, i.e., modeling existing SDN providers, compare the business models of the chosen organizations, and so forth. Design validation is accomplished by several expert reviews, which is introduced in the method validation (Section 2.2).

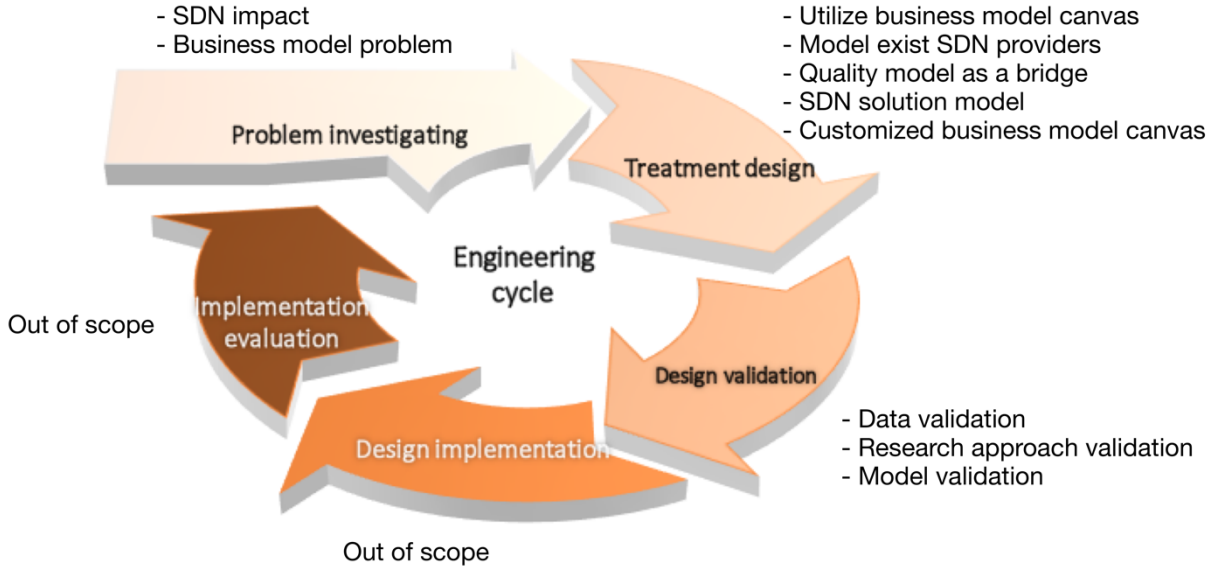

Figure 2-9. Research engineering cycle by Wieringa (2014)

Chapter 3 Theoretical background

The works of reviewing the existing literature will be shown in the following subsections. The scope of the theoretical background is within the business model, software defined network (SDN) and quality attribute (QA).

3.1 The business model concept

The business model concept is becoming increasingly prevalent in information technology, business strategy and management fields (Hedman & Kaling, 2003). There are over 2000 articles related to business model concept have been published between 2000 and 2015. Burkhart, Krumeich, Werth and Loos (2011) claimed that one of the most cited definitions is proposed by Timmers (1998). Timmers defines business models as "an architecture for the product, service and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenues." Instead of describing business model as an architecture and information flow for the stakeholders, Teece (2001) delineates BM as a method to explicitly label the fundamental components of an organization. In other words, it explains the way in which an organization delivers its value to the customers, how it attracts its customers to pay for its products and the way to convert these payments into profit. While Alt and Zimmermann (2001) define business model based on a six generic components, which are Mission, Structure, Processes, Revenues, Legal, and Technology. Based on previous researches, Osterwalder et al. (2005) brought forth a new definition, which combines the pre-studies. They defined business model as follows: "A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams" (Burkhart, Krumeich, Werth & Loos, 2011). Furthermore, Aziz, Fitzsimmons and Douglas (2008) conducted their research more objectively by defining business models on various components. Thus, they identified 54 business model components and ranked them on a score basis. Consequently, their definition contains ten essential elements that constitute business models. Even though many scientific papers have been focusing on defining business models, there is no consensus has been reached so far (Weill, Malone & Apel, 2011).

Despite the lack of formal definition of business models, however, it has emerged as a buzzword in business talk and practice - oriented journals, which underline the increasing shift from traditional to electronic business (Baden-Fuller & Morgan, 2010). Moreover, business model can be utilized for business and IT alignment, which means that the business model acts as a mutual means of communication between the business and IT domain (Osterwalder et al., 2005)

By using the business model, scholars can take a helicopter view of the SDN industry from all the aspects of a company to develop profitable services to its customers (Sinfield, Calder, McConnell & Colson, 2011). Shafer, Smith and Linder (2005) concludes that more than 40 different components of the business model have been defined during the past years. Many of those aspects are of crucial importance and cannot be dismissed, such as target customers, pricing approach, partnership relations. Therefore, it is essential to take a look at the business model of SDN before step into this emerging market.

3.2 Business model canvas

Even though there are many studies have been done on the topic of business model, it remains difficult to delineate its comprehensive components in a repeatable way. The main reason is caused by the complexity of the business processes in real life and the diversification of the combination of business model components. Especially when analyzing the business model at an instance level, it becomes hard to compare different cases with the traditional business model method. Hence, a module based, repeatable modeling technique is required.

Business model canvas has shown to be an efficient way of modeling the business. The concept has been used and tested around the world and is already used in organizations such as IBM, Ericsson, Deloitte, the Public Works and Government Services of Canada, and so on so forth. [16] It changes the way of the companies thinking from a product perspective to a business model perspective (Muhtaroglu, Demir, Obali & Girgin, 2013). The concept enables a shared language that allows us to easily describe and operate business models to build new strategies or improve the existing business models. (Osterwalder & Pigneur, 2010)

Business model canvas contains nine blocks that show the logic of how a company makes profits. These nine blocks cover four main areas of a successful business, which are customers, offer, infrastructure, and financial viability. It complies most of the components from the paper that Shafer, Smith and Linder (2005) have concluded. Furthermore, business model canvas has been successfully applied in an innovative IT market. Muhtaroglu, Demir, Obali and Girgin (2013) summarize and share their findings regarding the business models canvas deployed in big data applications. They analyzed the existing big data application using business model canvas and taking into consideration of the fundamental elements of business and illustrate how these applications make the profits by applying big data in their business. Moreover, Zolnowski, Weiß and Bohmann (2014) proposed a service business model canvas in their paper, which is established based on the business model canvas. They successfully apply the service business model canvas into the mobile payment service in the German retail industry.

3.2.1 Introduction of the nine blocks of BMC

As this research will extensively use the business model canvas to analyze the SDN providers on the market, this section will describe each block of the BMC by summarizing the explanation provided by Osterwalder and Pigneur (2010).

[16] http://www.businessmodelgeneration.com/canvas/bmc

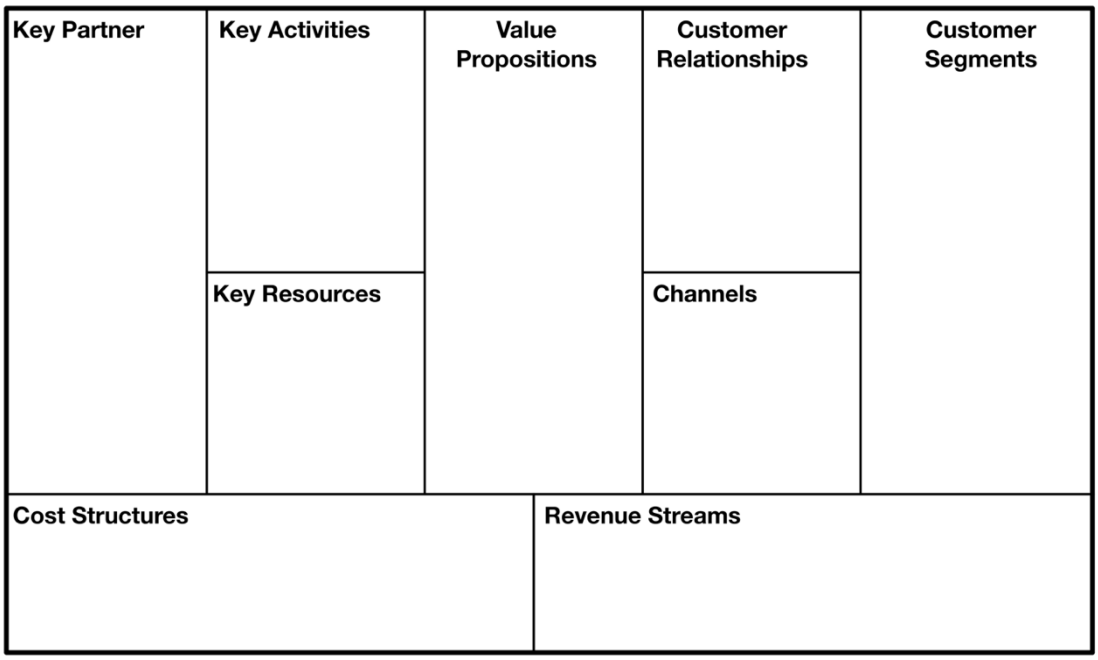

Figure 3-1. Business model canvas template

Customer segments

This block defines the different group of people or organizations an enterprise aims to reach and serve (Osterwalder & Pigneur, 2010). Customers usually play a significant role in any business model, because without owning profitable customers, no company can achieve a long-term success. To better satisfy and entice customers, this thesis categorized them into distinct segments. In a business model, it may have one or several large and small customer segments. In the book (Osterwalder & Pigneur, 2010), the authors provide several examples, such as **Mass Market**: A very broad customer segment that does not distinguish between different customer segments. **Niche market**, which is found in supplier - buyer relations. **Segmented**: Similar to a niche market, but it only has a very slightly different need and problems. For instance, banks set their customer into different level according to their credit records. **Diversified:** A company offers more than one separate customer segments with entirely different strategies. For example, the online retailer Amazon.com provide cloud service as a byproduct to take advantage of its powerful network infrastructure, which is unrelated to sell consumer products on the website. **Multi-sided platform**: An enterprise offers a platform for two or more customer segments to communicate or do business. For example, Apple AppStore, Alibaba.com.

Value proposition

Value proposition block creates the bundle of products and services that provide values for a particular customer segment (Osterwalder & Pigneur, 2010). It explains why customers choose one company over another. In other words, it solves the problems and satisfies their needs. Value proposition could either be an innovative new technology or a traditional service that keeps the customers stay. Osterwalder and Pigneur (2010) provide 11 elements of value propositions, for example, **Design:** It is hard to measure what a good design is, but it plays a significant role in some industries (e.g., fashion and consumer product). **Brand/status**: Most of the time, consumers will assume the quality of a product from a well-known brand is better than other products. Moreover, they believe such brands represent their social status.

Channels
Channel delineates how an enterprise communicates with its customer segments to deliver the value propositions (Osterwalder & Pigneur, 2010). It plays an important role to improve the customer experience. For example, **Delivery:** A fast, safe and cheap delivery will improve the customer satisfaction when they shop online. Channels can either be self-owned or partnered.

Customer relationships
Customer relationships building block illustrates different types relationship that a company establishes with certain customer segments. It helps the company to better span different customer segments after the relationships have been clarified. Customer relationships are driven by motivations such as customer acquisition, customer retention, and boosting sales. In the book from Osterwalder and Pigneur (2010), they provide a customer relationship example of a mobile network operator that is driven by aggressive acquisition strategies by providing customer free mobile phones. After the market becomes saturated, the operator will switch to focus on customer retention and increase the revenue from each customer. Based on the business needs, there are many types of customer relationships a company could follow. **Personal assistance** is based on human interaction, which means a real customer representative will be standby to offer assistances to the customers, e.g., call center, the point of sale. **Dedicated personal assistance** means a special representative will be sent to their customers' site to provide services. It is the deepest and intimate type of customer relationship that can help the company to develop a strong and long relationship with its customers. **Self-service** has no direct link with the customer but provides certain ways for customers to help themselves. **Automated service** is part of the self-service. **Communities** are seen as another effective way to retain customer relationships. Customers can interact with each other in the online communities to solve each other's problems. Moreover, companies can collect user data and feedback from such communities for further development. **Co-creation** can stimulate customer to participate and be better involved in the product, e.g., BestBuy asks its customers to write comments for the product they purchase; the comments and the product description together, become the product of other customers' view on the website.

Revenue streams
Revenue streams represent the way of how a company generates cash from each customer segment. A business model has two types of revenue streams, which are transaction revenues and recurring revenues. The former is a one-time payment from the customer, and the latter is an ongoing payment activity (e.g., customer will pay for post-sale service or additional product) that will last for a longer time. For examples, **asset sale** is a transaction revenue generates from selling a one-time product or service. **Usage fee** is based on a number of times or volume the customer uses the service or product, such as customer pay telecom carriers the minutes they spend on the call. **Subscription** fee is another type of recurring revenue, usually it is a membership or timely basis service. For example, monthly digital TV fees and train annual discount card. **Lending/renting/leasing** provide the customer the right to use a product over a period for a small fee rather than ask them to bear the full costs of the product. Licensing takes place mostly on the intellectual properties. It allows rights-holder companies to use the technical properties to generate revenues without manufacturing the real product themselves. In other words, they sell the intellectual properties to others.

Key resources
Key resources delineate the most significant resources required to enable the functions of the entire business model. Without the key resources, a company cannot provide value propositions, maintain relationships with each customer segments or make revenues. Key resources can be **physical**, **financial**, **human** (tangible) and **intellectual** (intangible). It can be created by the company, or leased, acquired from key partners.

Key activities
The key activities building block lists all the key things that the company must do to function successfully. Similar to key resources, key activities use key resources to create value propositions, maintain relationships with customer segments and make revenues. Key activities vary from different business model types. For example, a software company like Microsoft, its key activities must subsume software development. Categorized by Osterwalder and Pigneur (2010), there are three main types of key activities: **production** is related to design, make and deliver a product in large quantity, it mainly exists in the business model of manufacturing companies. Problem solving aims to provide new solutions to solve certain customer problems. The best example could be the consultancy companies; their key activities is providing professional solutions or training to their clients. Platform/network is another business activity used by companies who provide values via a platform, such as shopping website and AppStore.

Key partnerships
Key partnerships block explains the key suppliers and partners that help the company to fulfill the business processes. Partnerships can be used to optimize the business model, mitigate risk as mentioned in key resources about resources acquiring. There are four different types of partnerships: **Strategic alliance** between non-competitor companies, **cooperation** between competitors, **joint ventures** for entering a new market or business segment, **buyer and supplier** partnership to ensure a reliable supplier chain.

Cost structure
The cost structure describes all cost taken place to run the business model. In other words, it is the cost of performing the activities. Creating values, maintaining customer relationships and making revenue all generate costs. After defining the cost structure, it is clearer for the company to calculate the cost and make a wise investment decision for the future. There are two main cost structures based on the certain business model. **Cost-driven** business model aims to minimize the costs wherever possible because such business model has one fixed cost that cannot be easily decreased. For example, since the price of buying or renting a plane and the fuel cost of each trip are fixed, many cheap airline companies they do not provide free drinks or food during the trip, they only depart in small airports and in very early or late time to cut down the cost. Value-driven is another cost structure. Even though, costs should be minimized in all the business. Some high-end service providers, such as luxury hotels. They have to spend an enormous amount of money on their facilities and services so that the wealthy people will live in their hotels, by which, they can charge a higher fee for the services to make a profit.

3.3 Innovative IT Market Case: Software defined network (SDN)

Spence (1979) says, "a new industry or market is a potential market that has been created by technological innovation, a change in relative prices, or some similar event." Supply is way below demand, because the consumers are slow to change, and the product or services are still under developing. Thus, there are significant opportunities for firms to grow without generating excess capacity (Spence, 1979). In this thesis, the innovative market is software defined networking (SDN) market, which will be introduced in the following sections.

3.3.1 Problems in networking management

Unlike other parts of IT, making any changes in the network is still a manual process. When a company or organization wants to roll out a new application, they have to reconfigure every part of the devices in the network manually, which is a time and money consuming process. Moreover, it has grown up to be a handicap for the increasing demand for the cloud and web application services. A new paradigm in networking, Software Defined Network (SDN) enables a programmable network control by separating the traditional physical structure into control and forwarding (or data) plane (Jarschel, Zinner, Hoßfeld, Tran-Gia,& Kellerer, 2014). By doing this in an SDN network, a device is no longer only controlled by the internal controller (e.g., an internal system of a switcher). Instead, one SDN controller controls all the data forwarding planes in a network.

SDN centralizes the control of the data layer and enables a new generation of application – based network service for big organizations, data centers, and service providers.[17] It improves flexibility for the network in the following aspects among others:

- Traffic engineering
- Security
- Quality of Service (QoS)
- Routing
- Switching
- Virtualization
- Monitoring
- Load balancing

Many IT companies have seen this opportunity for future communication. For example, Cisco, HP, Citrix, VMware and some other open source providers have launched their SDN product and services. However, none of them are mature, i.e., none of them can dominate the market at the moment. Therefore, there is much market potential left there, as a later comer and a challenger, it is important to understand the best of the existing SDN business models and enter the market wisely. Even though, some researchers have already been done for SDN. Voellmy and Wang (2012) developed an extensible SDN control system that can significantly improve the scalability of an SDN network. Moreover, many other scientists have made a prominent contribution to the SDN field (Kim & Feamster (2013); Huang, Yocum & Snoeren (2013); McKeown, (2009)). However, little scientific research has been done to analyze the existing commercial SDN network, which becomes a barrier for companies to choose the right SDN provider, and for those who want to enter (or become the leader of) the SDN business in an effective way.

[17] http://www8.hp.com/us/en/networking/sdn/

3.3.2 SDN architecture

SDN is a business concept; its primary function is to decouple the data plane and the controller plane, and provide a network operating system to support various applications. However, the technical knowledge behind it is very complicated. In this section, it explained and simplified the technical knowledge so that the thesis can focus more on the SDN business model. SDN architecture (Reference Layer Model) was utilized to illustrate the essential SDN structures. In this thesis, the purpose of introducing the SDN architecture is not to start another research question for SDN, but to ensure:

1) The readers will have a better understanding of the high-level architecture of SDN, and
2) The readers are aware of the SDN functions (features) support which part of the SDN architecture.
3) The SDN architecture, as an important component in the SDN solution model, is well introduced beforehand.

According to the SDN architecture layer model proposed by Haleplidis, Denazis, Pentikousis, Salim, Meyer and Koufopavlou (2014), the authors mapped Cisco, HP, VMware and OpenDaylight's SDN products, both software and hardware, into the SDN architectural model. In this case, the authors can have a holistic view of what each company's SDN product or open source product's functions and features lie in the architecture in a technical perspective.

In the paper of Haleplidis et al (2014), they divided SDN architecture into three principal parts, the Application Plane, the Controller & Management Plane and the Network Device. There are four layers (Network Services Abstraction Layer, Control Abstraction Layer, Management Abstraction Layer and Device and Resource Abstraction Layer) exist between those three parts and connect them as a whole SDN architecture (Figure 3-2).

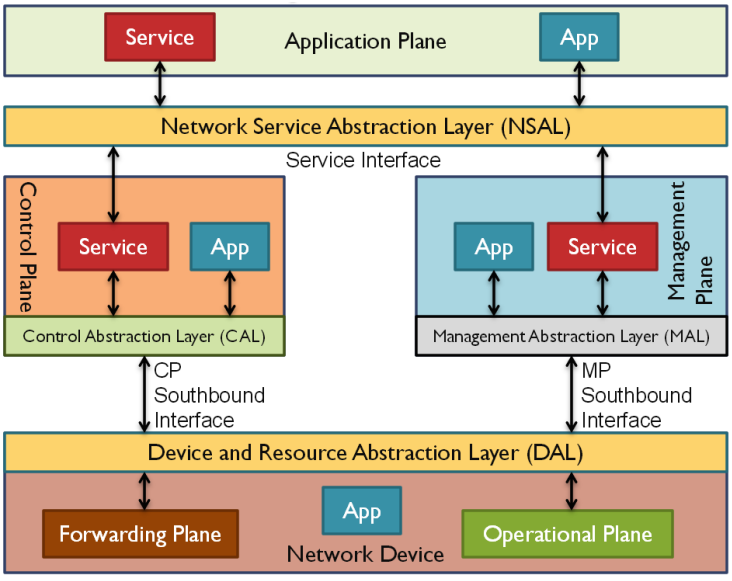

Figure 3-2. SDN architecture (Haleplidis, et al, 2014)

Application Plane
The Application Plane is where the applications and services that define network behavior reside. Applications can be implemented in different modular and thus, application plane can span multiple planes in the SDN layer architecture. Moreover, note that the applications directly or primarily support the operation of the forwarding plane are not considered as part of the application plane (Haleplidis et al, 2014)

Control Plane
The control plane plays a role as a decision maker in the SDN architecture; it decides which packet should be forwarded by one or more network device and deliver such decisions to the network devices for execution. The control plane focuses more on the forwarding plane rather than the operational plane. However, the control plane needs the operational plane information as well, such as the current state of a particular port or its capabilities. In brief, the main task of the control plane is to fine tune the forwarding table in the forwarding plane based on a certain network topology or some extra requests from outside.

Management Plane
Management plane is responsible for monitoring, configuring and maintaining network devices. The management plane focuses mostly on the operational plane in the network device and less on the forwarding plane. It can be used for configuration for the forwarding plane, but it is infrequent, and once the configuration is done, it will not change it anymore.

Network Device
A network device is an entity that receives packets on the ports and apply its network functions on these packets. For instance, a network device can receive and forward a packet, drop it, modify the header, forward the packet. A network device consists of multiple resources such as CPU, ports, memory, and queues. Switches and routers can be seen as network devices. Moreover, additional examples can be regarded as network device as well (e.g., network elements such as firewalls, load balancers, and video transcoders). Network devices can be implemented both in a hardware device and software device (virtual device). In the paper of Haleplidis et al (2014), they make no distinction between network hardware device or virtual device.

Before explaining the different layers, the term of service must be clarified in the SDN architecture. Service means a software that provides one or more functions and APIs to applications or other services in the same or different layers. Services can be bundled with other services, or can be used to create a new service (Haleplidis, Denazis, Pentikousis, Salim, Meyer & Koufopavlou, 2014)

Network Services Abstraction Layer (NSAL)
NSAL offers service abstractions that can be used by applications and services. In other words, there is a bridge that connects the applications and services in application plane to the applications and services in the controller and management plane. One example could be the northbound Representational State Transfer (REST) API.

Controller Abstraction Layer (CAL)

It is the abstraction layer in the controller plane; it provides access to the applications and services in the application plane to its southbound interface, which then connect the applications and services to the network device for further functions.

Management Abstraction Layer (MAL)
It provides access to the management plane southbound interface, which is likewise to the CAL but focus more on the functions of management and operation.

Device and Resource Abstraction Layer (DAL)
DAL bases on one or more models, which means if it is a physical device, it can be referred as Hardware Abstraction Layer (HAL). Otherwise, it is for the virtual network device. It provides a stable point of reference for the device's forwarding and operational plane in the network device.

3.3.3 Background of SDN

Back in the mid - 90s, the Internet was starting to reach its success. However, shortly, it was found that the fast growth of the Internet is facing an enormous obstacle towards the complexity of managing the network infrastructure. Network device manufacturers build their products as a black box to support specific protocols for the operation of the network (Foukas, Marina & Kontovasilis, 2014). The Open Signaling working group (Campbell, Katazela, Miki & Vicente, 1999) and the Active Networking (Tennenhouse, Smith, Sincoskie, Wetherall & Minden, 1997) are two of the early researchers about the separating the control plane from the hardware data plane. They proposed a concept of programmability in Asynchronous Transfer Mode (ATM) networks. Especially the Active Networking played an impact role in the pursuit of programmable networks because most of the concepts end up with contributions to the SDN model. Such as the separation of the control and data plane, using network API. However, the lack of compelling problems did not lead these approaches to success (Qadir, Ahmed & Ahad, 2014; Feamster, Rexford & Zegura, 2013). Other reasons such as they focused on the wrong user group and promoted more on the data forward plane than the controller plane result in failures of these initiators (Hui & Koponen, 2012). After more intermediate attempts and projects, such as ForCES (Yang, Dantu, Anderson & Gopal, 2004), 4D project (Greenberg, Hjalmtysson, Maltz, Myers, Rexford, Xie & Zhang, 2005) and Ethane[18] in Stanford University. Finally in 2010, the researchers at Stanford created the Clean Slate Program[19], which uses the OpenFlow protocol as a mean for running experimental protocols. The OpenFlow solution, later on, became one of the most popular architectural solutions for the programmable network (Foukas, Marina & Kontovasilis, 2014), which leads to the new paradigm of Software Defined Network (SDN).

However, there is a lack of cumulative research as most publications propose the alternative or new models of SDN rather than evolving existing businesses. Furthermore, despite the increased number of organizations competing for the SDN technology, there are still some obstacles that can slow down the entire adoption for SDN, as stated in SDx Central's market size report 2015[20], including:

[18] http://yuba.stanford.edu/ethane/pubs.html
[19] http://cleanslate.stanford.edu/#
[20] https://www.sdxcentral.com/reports/sdn-nfv-market-size-forecast-report-2015/

- Complexity of the solutions

Since 2013, there are already many successfully SDN deployments in production. However, the number of full SDN deployment is still in a small portion. Therefore, the demand for SDN is prominent, and the complexity of rolling out is much higher.

- Shortage of adequate skill sets

Although the increasing of SDN is significant, the lack of strong training and skill-set within the organization are still the barriers for the development of SDN. As an automated, programmable and easy scalable networking technology, the traditional highly specialized network engineers may not have the ability to handle it. In a more programming networking management workforce, experienced software developers are the better fits for this requirements.

- Difficulty in integrating with real-world production systems

The report says that the integrating of SDN to exist network and the interoperability between SDN and non-SDN networks remains, even for some of the extensive network vendors.

- Inadequacy of virtualization infrastructures

This issue is particularly happening in Network Function Virtualization (NFV)

Accordingly, this paper aims to propose a method to help new market entrants to design and develop a business model in the IT industry. It will take SDN as a case to conduct an in - depth study on the exist SDN solutions by applying the Business Model Canvas.

To accomplish this goal, the authors have analyzed four mainstream SDN providers in the IT market by using Business Model Canvas. A matrix is created based on the different blocks of BMC and SDN situations. The entire method of the modeling process consists of four steps (Figure 3-3):

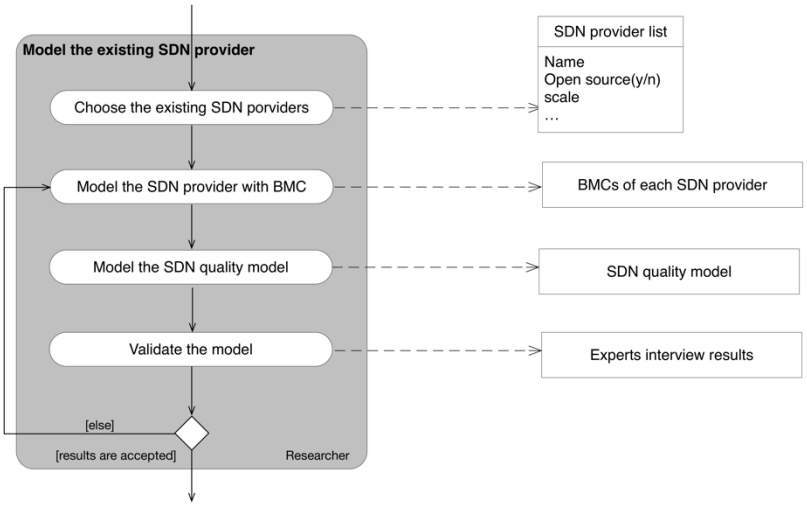

Figure 3-3. Process of exploring and defining existing business model

Similar to the overall research approach, the authors use PDD to model this "model the existing SDN provider" process. It contains four steps, and each of the steps will generate a deliverable. There is an iterative step when validating the model with case companies, if the results are accepted, it can then move on to the next phase; otherwise it will go back to the second step of "modeling the SDN provider with BMC." More details can be found in the tables below.

Table 3-1. Activity table of the PDD of Figure 3-3.

Activity	Sub-activity	Description
Model the existing SDN provider	Choose the existing SDN providers	In this step, the researcher will select the existing SDN provider in the market.
	Model the SDN provider with BMC	After choosing the SDN providers, the researcher will model their SDN solution/product by using business model canvas.
	Model the SDN quality model	In this step, the researcher create a quality model based on the ISO 25010 and prior studies from Haleplidis, et al., (2014) and Metzler, Metzler and Associates (2013). Those SDN features will be stored in SDN FEATURE LIBRARY for the purpose of SDN function mapping.
	Validate the models	The BMCs and SDN architectures will be validated in this step by interviewing some experts from the chosen organizations or experts who are certified and are experienced in a certain organization's products. The results can be used to revise the matrix to get the final IMPROVED MATRIX.

Table 3-2. Concept table of Figure 3-3

Concept	Description
SDN PROVIDER LIST	This deliverable is used to list the chosen SDN providers. It is generated from an SDN market report from ESG Market Landscape Report on SDN (2013)
BMCS OF EACH SDN PROVIDER	Business model canvas for each organization.
SDN quality model	SDN quality model describes the key SDN functions and categorizes them into fourteen quality attributes, which are divided into three parts as the SDN architecture.
VALIDATED BMC COMPARISON RESULTS	It is the BMC results generated after the validation with experts' review. It will influence the outcome of IMPROVED MATRIX.

3.4 Quality attribute

It is hard to match the business model with the SDN architecture, because in the business model, the focus is on the business activities, such as customer relationship, partnership, revenue stream. However, in the SDN architecture model, the components are displayed in the technical perspective, which elaborate the functions and features of the SDN product. McDavid (2003) mentioned that the industry has gotten very adept at dealing with such gap, which is the architectural approach. An architected view provides the business people with the same benefits as an architected view of software to the developers and software engineers. In that case, the architectural approach arose the recognition of functional and nonfunctional features of business as well as in software requirements. Similarly, enterprise architecture (EA) is one of the architectural approaches that is used on an enterprise level architecture that captures the essentials of business as well as the IT evolutions (Jonkers, et al., 2006). They also mentioned that in an increasingly networked world, the enterprise should not focus solely on its own operations, but also to get a grip on the wealth of interconnections with its supplier, customer and key partners. Therefore, a well-defined enterprise architecture can cover all the focal points. However, there are many more obstacles for those big enterprises to make a change. Kotter (1995) stated that over the past decade, he have watched more than 100 companies try to make

themselves into remarkably better competitors. However, only a few of them succeed, a few of them got into utter failure, most of the organizations fell in between. Change management is thus not an easy task. Hence, to solve such problem with fewer changes and impacts on the existing architecture and business model of the company, it is required to find a middleware or extension point to bridge those two sides. Unfortunately, few literatures have brought out any solution to fill this gap. Therefore, the authors propose to use quality attribute (QA) to interpret the technical jargons into the standard X-ability term, which, in some way, are closer to the business definition and can connect the BM and the SDN architecture.

3.4.1 Quality attribute (QA)

Quality attribute is defined as "a measurable or testable property of a system that is used to indicate how well the system satisfies the needs of its stakeholders" (Bass, Clements & Kazman, 2012). According to Bass, Clements and Kazman (2012), system requirements encompass three different categories.

Functional requirements

These requirements explain what are the main functions of a system, how the system must behave and react to user interactions. In the case of SDN, this is what are displayed in the SDN architecture, where all the features, functions, and technologies being implemented in an SDN product. For example, the application plane in SDN architecture provides an interface that can add as many and different applications as customers want, such as load balancing app, security firewall apps, monitoring apps. All of these functional attributes cannot be mapped to the business model, which, then create a so-called "Business - IT Gap" (McDavid, 2003) that prevents or postpones organizations to use the cutting edge technology. In other words, the business value of using such tools is not clear. Therefore, people may refuse to use or misuse the new technologies.

Quality attribute (QA) requirements

These requirements are the qualifications of the functional requirements, or of the overall product. Functionalities often play a leader role in the development phase of a product. However, systems are frequently updated and even redesigned not because of the functional deficient, but the quality of the functional attributes. For instance, the system can process what it should do, however, the speed is too slow. Alternatively, the system is fast, but the security capability is low. QA, therefore, is used to delineate such qualifications of the functions of a product.

Constraints

A constraint is a design principle with zero degrees of freedom. It is usually from the business requirement or the development team. For example, a product must be compatible with the current products the company is using so that developers have to use a certain programming language.

3.4.2 Quality attributes and the business model

Ozkaya, Kazman and Klein (2007) argue that architects often make architectural design decisions but hardly able to evaluate their economic impact. The reason lies in the fact that managerial level they only interested in product - level decisions (e.g., quality, features and customer requirements) but not in the technical details of how those decisions are fulfilled. As a consequence, this may lead to inconsistencies between the understanding of the executives and

how the architect will design and develop the value propositions of a product. Ozkaya, Kazman and Klein (2007) mentioned that those inconsistency information exchange is particularly critical when an organization is going to plan for an architecture evolution in an uncertain and new future business, such as SDN, a fast growing market, however, difficult to foresee its future. Although the industry advocates that SDN will be the next generation of networking; it is still in its baby age. Any unforeseen impact may change its path, or some new technology may even replace it. For example, the disc storage of CD, VCD, and DVD. Later, the hard drive appeared, then emerged the solid state drive (SSD) and cloud storage. It turned out that each storage technique was replaced by another in a few years. Hence, there is always a risk to invest heavily in new technology. The future value of a product or technology is uncertain.

Modularity has been an appealing design strategy to create future value in the form of real options, a finance concept (Baldwin & Clark, 2000). It is a quality of a system that composed of several parts that cooperate with each other well. Properly structured modularity architecture support modifiability, which is the degree of a software system can tackle with change. Baldwin and Clark (2000) stated that the design of an architecture is a real asset when it is expressed in terms of real option. However, that approach ignores the impact of the mis-interaction among those quality attributes when an architectural decision is made (Ozkaya, Kazman &Klein, 2007), which results in a lack of supportiveness for a modular design to support the performance or other QAs.

Ozkaya, Kazman and Klein (2007) introduced a practical method selecting design patterns of utility and uncertainty of architectural requirements and future value on overall architecture, which leads to a better decision-making at the end. In their research, they use the real option theory (Amram & Kulatilaka, 1999) to analyze the value of architectural patterns in terms of QA, thus, they can offer help to the achievement of software architecture. The goal of their research is to provide guidance to make a tradeoff design to achieve the business goal as well as the architectural flexibility.

As the author have discussed above, this thesis will not use QA to design a new architecture, neither business architecture or technical architecture. This research was conducted after the SDN products were made, thus, the focus will lie on eliciting the QA from the existing SDN products and match them to the existing business models.

Chapter 4 SDN organization selection

In this section, a selection process will be introduced, and it will be utilized to select the case organizations from the current SDN providers.

4.1 Selection method introduction

As in Chapter 1 has stated above, there is no dominant organization in the SDN market at the moment. Thus, it is a challenge for us to select the appropriate companies. To make this process unbiased, the authors use a market landscape report from Enterprise Strategy Group (ESG)[21]. ESG is an integrated IT research, analyst, strategy, and validation firm that is world-renowned for providing actionable insight and intelligence to the global IT community. Several mainstream SDN companies will be extracted from ESG's report, based on which, a further investigation will be conducted and a comprehensive company list will be provided. In the fact that ESG only studies on the profit organizations, it misses a significant role in the IT market -- open source project. Therefore, similarly, the authors have selected one open source project into their case organizations as well. The entire process is modeled in a process deliverable diagram (PDD) in Figure 4-1.

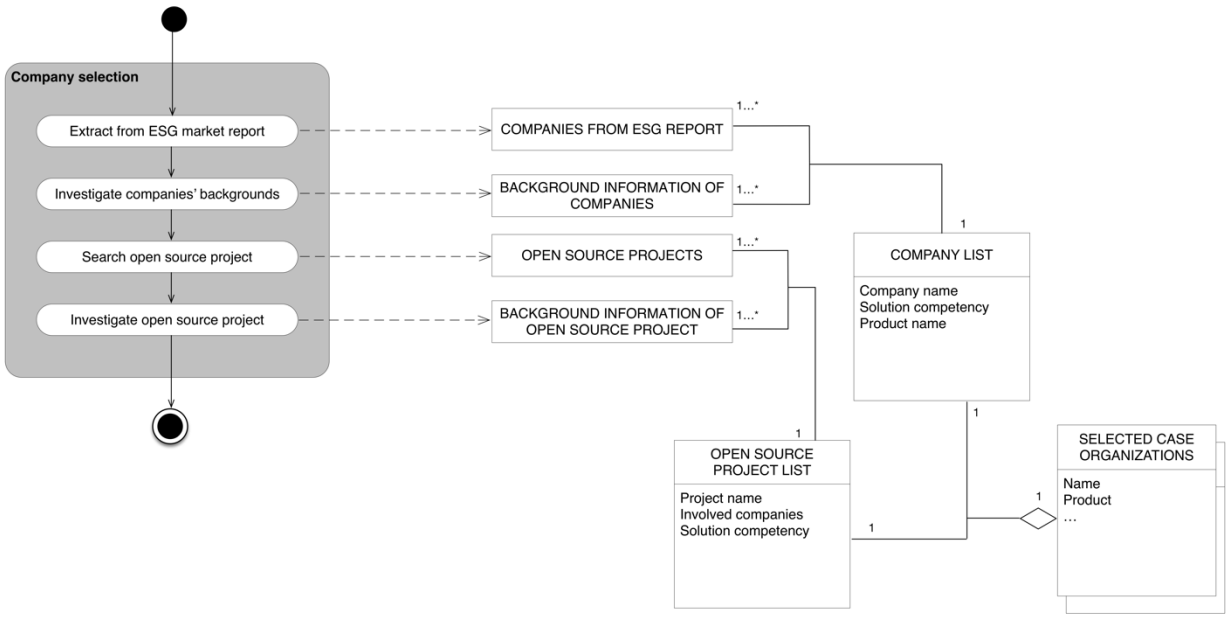

Figure 4-1. Company selection process

[21] http://www.esg-global.com

Table 4-1. Activity table of Figure 4-1.

Activity	Sub-activity	Description
Company selection	Extract from ESG market report	In this step, the researcher will read the ESG Market Landscape Report on SDN (2013), and extract all the company from the report for later analysis.
	Investigate companies' background	Categorize all the company into different groups and start the analyzing process.
	Search open source project	Search the SDN related open source projects in the market
	Investigate open source project	Analyze the chosen SDN open project and choose the case organization for later comparison.

Table 4-2. Concept table of Figure 4-1.

Concept	Description
COMPANIES FROM ESG REPORT	The company names from ESG Market Landscape Report on SDN (2013)
BACKGROUND INFORMATION OF COMPANIES	The background information contains the SDN solution competency, main SDN product.
OPEN SOURCE PROJECT	The open source SDN projects the authors chose from the market.
BACKGROUND INFORMATION OF OPEN SOURCE PROJECT	The background information of founded time, member number and focus areas.
COMPANY LIST	This company list is selected from the COMPANIES FROM ESG REPORT.
OPEN SOURCE PROJECT LIST	The OPEN SOURCE PROJECT LIST is the open source project the authors choose from the OPEN SOURCE PROJECT
SELECTED CASE ORGANIZATIONS	The SELECTED CASE ORGANIZATIONS are the names of organizations the authors are going to investigate in this research.

4.2 Extract companies

Due to the fast changing of this new market, it is difficult to pick up the appropriate companies for analysis. According to the ESG Market Landscape Report on SDN (2013), there are different paths for the vendors to get to the SDN stage. Some are active in all the fields (e.g., SDN controller, network virtualization, vSwitch, SDN standard switch) with open industry standards, while others take a more open vendor - specific approach; some are very proprietary; and some are investigating a hybrid approach to combine more than one method. The report outlines a list of companies that are actively engaged in the SDN business. As it states, it is not exhaustive.

Brocade
SDN providers

Table 4-3. SDN providers in ESG's report

SDN Provider				
Arista	BigSwitch	Brocade	ConteXtream	Cisco
Dell	Enterasys	Extreme	HP	IBM
Juniper Network	Nuage Networks	NEC	Midokura	Pica8
Plexxi	Vello	VMware		

4.3 Investigate companies' background

Some of the companies focus only on network virtualization (e.g., VMware); they do not provide physical switches. Others may only have physical switches or stay alone with SDN controllers. To clarify the background of these companies, the authors build a company table below, which indicates the description for the target companies in Table 4-4. (SDN vendors)

Table 4-4. Company list from ESG market report (first six rows, full table could be found in Appendix)

Providers	Solution competency	Main product
Arista	Cloud Networking Network Virtualization Network Programmability	EOS+ Switches
BigSwitch	Hyperscale Networking Switch Software Solution Fabric Analytics	Big Tap™ Monitoring Fabric Big Cloud Fabric
Brocade	Management Operations Server Virtualization IP Storage Networking	Switches Routers Brocade SDN controller (Vyatta controller)
ConteXtream (Acquired by HP)	NA	NA
Cisco	Business Continuity Desktop Virtualization Management Operations Network Virtualization Server Virtualization Software-Defined Storage	Evolved Services Platform (ESP) Application Centric infrastructure (ACI) Cisco Application Policy Infrastructure Controller (APIC) ONE Software Switches and routers
Dell	Hybrid Cloud Mobility Management Network Virtualization Server Virtualization Software-Defined Storage	Dell OS9 Active Fabric Controller (AFC) - for OpenStack environment. Switches (N, S, Z series)

According to Table 4-4, these companies can be categorized into two categories, namely Software (Network virtualization) focused company, and hybrid-active companies. See Table 4-5.

Table 4-5. Software focused company and hybrid-active company

Category	Companies
Software (Network virtualization) focused company	VMware, Vello, Midokura, Nuage Networks, IBM (OpenDaylight based solution, not specific)
Hybrid active companies	Plexxi, Pica8, NEC, Juniper Networks, HP, Extreme Networks, Dell, Cisco, Brocade, Arista, BigSwitch

The authors decide to select the case companies based on their popularities in this market. On one hand, an SDN provider network was built (Figure 4-2) to illustrate the relationship among the SDN providers in the market. The network is based on the partner relationship of the companies by applying social network methodologies such as betweeness centrality[22] and

[22] https://en.wikipedia.org/wiki/Betweenness_centrality

modularity class[23]. Note that when investigating the companies in Table 4-5, the authors subsume their partners into the SDN provider network, which are not list in the report. Thus, there are more companies and organizations in Figure 4-2.

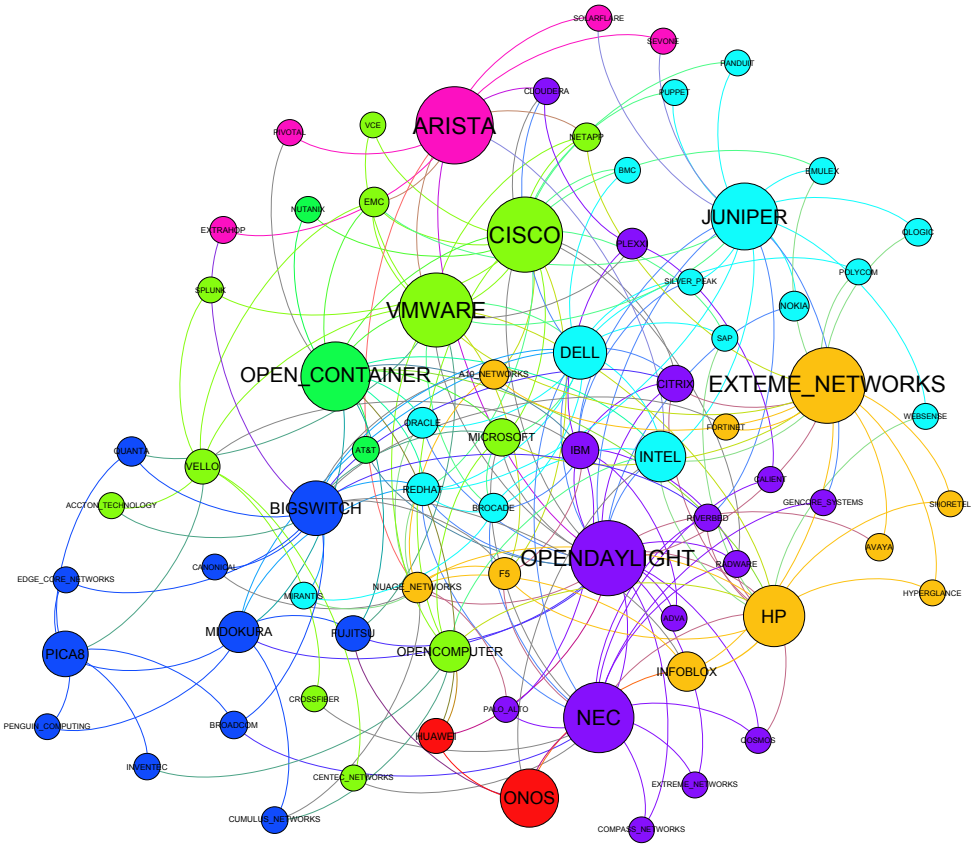

Figure 4-2. SDN provider network

The size of the nodes is based on "Betweenness Centrality", it indicates influential nodes for the highest value, i.e., the bigger the node, the higher density for the partnership of that organization is. For example, OpenDaylight is bigger than Cisco, because it is an open source project with a bigger partnership size. Even though Microsoft and Google are two of the biggest IT companies in the world, however, their sizes are smaller than Juniper, it is because they are not as active as Juniper in the SDN market.

The colors of the nodes are based on "Modularity Class". It divides the organizations into several communities in different colors. For instance, in Figure 4-2, it shows that Cisco, VMware and Open Container Project are in one community because they share more same partner companies.

Another direct and efficient way is to use Google Trends, which bases on the search term from Google Search - the biggest search engine in the world. Although it is not 100% accurate and is not proven as a sufficient way to analyze the popularity of a product, the authors believe it is the best tool to provide an insight of what are people searching. Moreover, the purpose of using

[23] https://en.wikipedia.org/wiki/Modularity_(networks)

Google Trends is not to find the best companies in SDN or to help people to choose SDN products, but to select some case companies in a very early stage. Therefore, the authors choose Google Trend to do the popularity analysis to select the case companies.

There are several exploring conditions in Google trend engine that need to be set up before inserting the key words. The search scope is set to "worldwide", because not only in the western countries but also in Asia, like Japan, China, South Korea's companies are playing an important role in the networking industry. The time period is set from "January 2008 to June 2015", albeit the concept of programmable networks dates its origins back in the mid-90s, the emergence of SDN happened in the second half of the 2000s (Foukas, Marina & Kontovasilis, 2014). The category is set to "all categories" and search method is set to "web search". After the exploring conditions are set, all the search term combinations are inserted as "company name + sdn", e.g., "cisco sdn".

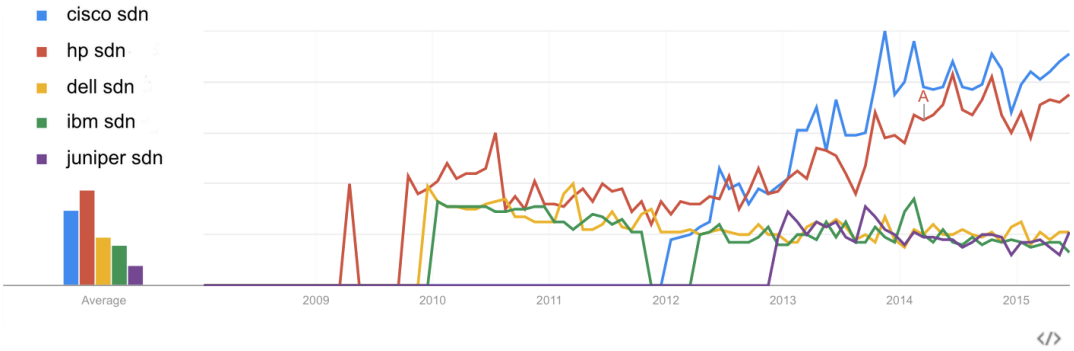

Figure 4-3. Google trends of SDN vendors (Hybrid active companies)

After putting all the combinations into Google trend engine, it showed that the top 5 most popular companies. Blue is "cisco sdn", red is "hp sdn", Orange is "dell sdn", green is "ibm sdn", Purple is "juniper sdn". The rest of the companies are way below the average. As a consequence, only two companies are chosen (whose popularity degree is much higher than the average), they are Cisco and HP.

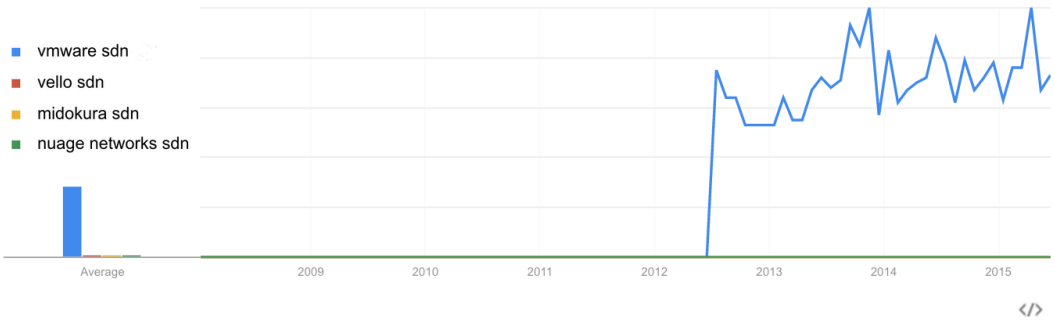

Figure 4-4. Google trends of SDN vendors (Network Virtualization)

By applying the same criteria to the network virtualization focused SDN vendors, the authors created the Google Trends line chart in Figure 4-4. Since only one company shows a significant search popularity in Network virtualization, the authors decide only to subsume VMware (the blue bar). The search trends may differ later on because the fast changing pace of this SDN

market, the results collected is appropriate as an indication for company selection, and to study the business model and product architecture for SDN market.

To easier compare the features and cover as large the aspect as possible, the researchers will choose Cisco, HP and VMware in the list. Cisco is playing a leader role in the networking industry for years; they are offering a proprietary SDN product - onePK[24] with a well organized open ecosystem. As stated by Cisco (2015), an SDN data center automation framework should not be designed as a monolithic, proprietary architecture. The industry requires an open, extensible, multivendor architecture that can be deployed in a variety of products and open source solution. Thus, albeit the core product is proprietary, Cisco's SDN products have a high open standard for integrations. It plays a significant role in many SDN open source projects, such as OpenDaylight, OpenStack, and OpenFlow. Furthermore, Cisco has a broad range of SDN products and a complete service stream. Hence, the authors select Cisco as one of the case companies. HP, another essential player in the SDN market, who is one of the initiators of the Stanford SDN project and is involved in some of the popular standards, for example, OpenFlow and OpenStack. Additionally, it provided the industry's first SDN app store. AppStore, which is considered as the most successful ecosystem for app distribution since Apple launched the first App Store in 2008. Thus, HP will be another case company in this thesis. On the other hand, as the authors have mentioned above, VMware is focusing on network virtualization. Due to the difficulty of migrating from the traditional network to Software Defined Network, network virtualization is a money - saving decision for many organizations. Even those hybrid player (e.g., Cisco, HP), they have their own hybrid network solution to let the customers keep their traditional networks while starting to use the SDN. VMware is one of the key partners for many big companies for their network virtualization technology. Thus, VMware will be the case company as well. Nevertheless, other networking companies are also playing a key role in the SDN market. However, those differences and unique characteristics of those three companies intrigues us to make further analysis on them.

4.4 Search open source projects

Open source plays a significant role in the IT industry. It not only facilitates the success of open source companies (e.g., RedHat[25], Ubuntu[26], Mozilla Firefox[27], CyanogenMod[28]) but also enables the commercial companies to bring successful products. For example, MIUI, a mobile phone operating system developed by Xiaomi[29] Tech in 2010, is based on Android and CyanogenMod source code. This UI and the hardware devices made Xiaomi Tech become the leader in smartphone market in China with a 15.9% market share according to CNET's report (2015). Chesbrough (2006) argues that innovation processes are always beyond organizational and geographical boundaries, which is always open and distributed. It indicates that new technology innovation can be invented through important inputs from a variety of external sources (e.g., consumer feedbacks, competitors, public research institutions, universities and

[24] http://www.cisco.com/c/en/us/products/ios-nx-os-software/onepk.html
[25] http://www.redhat.com/en
[26] http://www.ubuntu.com
[27] https://www.mozilla.org/
[28] http://www.cyanogenmod.org
[29] http://www.mi.com/en/

other organizations), rather than only from a firm's internal R&D center (Von Hippie, 1988). Thus, the authors decide to include some open source projects into this research.

The main principle of selecting the open source project lays on the feasibility of analyzing the project with a business model. In other words, it should possess a complete SDN controller product so that it can be compared to other companies. Controllers are pivots between switching and SDN application, without the support of an outstanding SDN controller, the programmable network will not be capable. According to SDx Central's open source project directory[30], in the category of "Controller and Network Operating System", the authors selected OpenDaylight Project, Open Computer, Open Container and ONOS as case candidates for open source project.

4.5 Investigate open source projects

Likewise, in the process of investigating the companies in Section 4.3, the authors have built a description table for these open source projects. See Table 4-6.

Table 4-6. Open source project description

Name	Founded time	Member number	Focus area
OpenDaylight	2013.04.08	50	Multi-protocol controller
Open Computer	2011.04	17	Storage, Networking, Server design, Open Rack, Hardware Management, Datacenter, OCP Archive
Open Container	2015.06	35	Open industry standards around container formats and runtime
ONOS	2014.11	25	SDN controller

Based on the member number and founded year, the authors intended to choose between OpenDaylight and ONOS. Although Open Computer was founded in 2011, it has only 17 members, which may not output a market impact. However, the member number in ONOS, which is 25, also does not provide a strong reason to subsume it into this research. Thus, likewise to the selection process for the commercial companies, the authors decide to use the Google search trend (Figure 4-5).

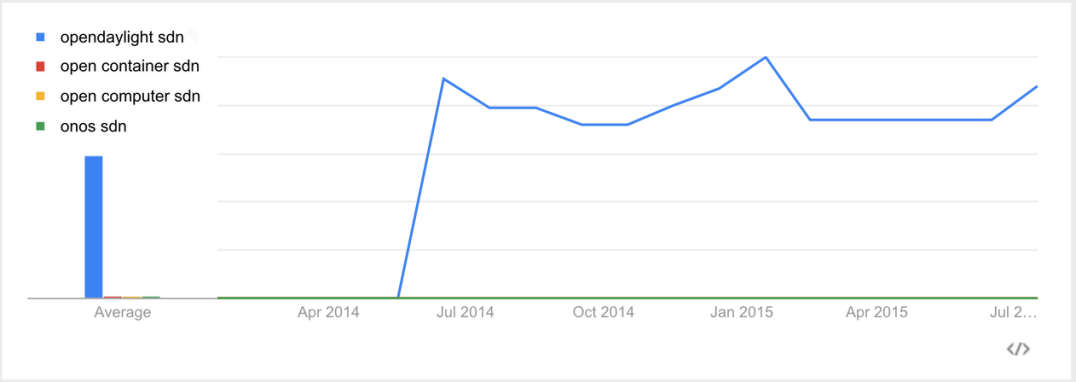

Figure 4-5. Google trends of open source SDN organization

The Google search trend for open source organizations follows the similar search condition that set up for the proprietary companies. The search scope is set to "Worldwide", the time period is

[30] https://www.sdxcentral.com/resources/sdn/sdn-controllers/open-source-sdn-controllers/

set from “Jan 2014 to July 2015” because when entering an earlier time frame, it shows nothing in the graph, which means open source SDN software become popular in later 2013. Categories are set to “all categories” and search method is set to “web search”. The authors used their names as the keywords at the beginning, but it shows some biased results, because Open Computer and Open Container means something else. So a combination of the organization’s name + “sdn” is used again.

The results (Figure 4-5) show that OpenDaylight has a significant popularity compared to the other three open source SDN organizations, which is confirmed later in the interview with the experts. When talking about open source software in SDN, OpenDaylight always takes the lead.

OpenDaylight was started and supported by some well-known IT companies, such as Cisco, IBM, Dell, Ericsson, Intel, Huawei. It provides a highly available, agile and scalable SDN platform aims to comply all the standards in the SDN industry. The latest release of OpenDaylight called Lithium[31], it allows service providers to compose their service architectures or leverage an OpenDaylight – based commercial offering to deliver dynamic network service in a cloud environment. Moreover, service providers can use OpenDaylight to craft dynamic intent-based policies and begin virtualizing functions with Service Function Chaining (SFC). It is currently one of the most popular and active SDN controller open source projects in the market. Therefore, the authors chose to include OpenDaylight as the open source product into this analysis. It is important to note that these four organizations that have been chosen are not exhausive that can cover every aspect in the growing SDN market, but it is considered to be an appropriate appropriative choice at the moment.

Table 4-7 displayed the final four organizations that were selected as our analytical context in this thesis.

Table 4-7. The chosen five SDN organizations

Selected SDN organizations	Description
Cisco	Hybrid active SDN provider with various of SDN solutions, e.g., Application centric infrastructure
HP	Hybrid active SDN player with a OpenFlow standard SDN solution and the industry first SDN AppStore.
VMware	Network virtualization-focused company.
OpenDaylight	Leading SDN open source project

[31] https://www.opendaylight.org/lithium

Chapter 5 SDN business model canvas modeling

After the selection of the analytical context, i.e., the SDN organizations (Table 4-7), we have modeled them via business model canvas. In this chapter, four BMCs from the selected organizations will be presented. The author collected all the data from those organizations' websites, focusing on their products information, sales channels, after sales services, help desk, developer communities, partners, social activities, and so forth. Besides, we reviewed the technical white papers, development documents and support forums to further understand their product value propositions. After presenting all the BMCs of those four organizations, a BMC critical feature matrix will be provided, and those four organizations were compared. A conclusion was given at the end of this chapter to describe the scientific contributions of the business model canvas modeling in this chapter.

5.1 BMC of HP

Figure 5-1. BMC of HP SDN Strategy

Customer Segments

HP's industry first SDN Appstore help it to establish a multi-sided platform. Customers consist of both SDN users and SDN App developers. SDN App developers are part of HP AllianceOne partner program[32]. Thus, SDN App developers are partners as well. HP add OpenDaylight (ODL) controller to its Appstore recently, which means developers can work for both VAN and ODL.

Value Propositions

The multi-sided platform of HP's SDN ecosystem proposes not only business values to their SDN product users but also creates a brilliant way to connect the developers and users. Furthermore, HP provides a migration service to help their customers transform from the

[32] http://h21007.www2.hp.com/portal/site/dspp

conventional network to SDN at their paces. Customers can use an HP hybrid SDN architecture to keep using their traditional infrastructure at a low cost.

Channels
HP's most innovative channel is the industry's first and only SDN AppStore. Although it shows that it only binds to SDN App Developer in the BMC, it serves both of the customer segments. However, at this beginning stage for HP's SDN AppStore, the authors believe HP need more SDN Apps to draw more attention in the SDN market, so HP currently charges nothing from their developers. The AppStore ease the app deployment process, which can help the developer to focus on the products developing activities.

Customer Relationships
HP serves two different markets with different dynamics. Relationship with SDN product user, which subsumes Dedicated Personal Assistant that offer paid solutions and services. Moreover, Self - service for E-learning and webinars. Relationships with App developers consists of development support and SDN Appstore.

Revenue Streams
HP's SDN revenue stream composes of two parts.One is the products and services sold to SDN product users, e.g., the customer could be enterprise, data centers, and campus. The other is the AllianceONE partner program. Developers have to pay for HP's products, for example, the HP VAN Controller has an only 60-day free trial. Moreover, training and development support service cost a fee as well. By selling its infrastructures (e.g., switches and routers), they can also make a profit.

Key Activities
Since this BMC focuses only on HP's SDN strategy, the main activities are divided into five parts. Namely, SDN platform management, service provisioning, platform & product promotion and SDN product development (R&D for SDN product). Note that besides internal R&D, HP has been involved in many SDN open source projects, like OpenDaylight, OpenFlow.

Key Resources
Key resources of HP's SDN ecosystem are mainly consists of their SDN Appstore, SDN products and their SDN experts who provide networking services and solutions. Note that those experts can both from HP itself and its partner. For example, HP works with PwC closely to provide SDN consulting. Moreover, according to the interviews with HP SDN experts, they mentioned a very critical resource for HP, which is the SDN vision they have. HP is one of the first contributors to the Stanford OpenFlow project and developed the industry first SDN AppStore.

Key Partner
Similar to other big companies, Apple, Cisco, Nike, etc. HP outsource its supply chain to other manufacturers[33] so that they can devote more efforts into products development and service provisioning. HP SDN Ecosystem Alliances offer HP with a strong competitive capability in this

[33] http://www8.hp.com/h20195/v2/GetDocument.aspx?docname=c03728062

emerging industry. Furthermore, being a platinum member in OpenDaylight and actively attending in many other open source projects, makes the open project partners become one of the most important partners for HP.

Cost Structures

The cost stream of HP's SDN strategy contains four principal parts, which are maintaining and developing SDN AppStore platform, maintaining and developing SDN products, marketing and open project investing.

5.2 BMC of VMware

Figure 5-2. BMC of VMware Network Virtualization NSX

Customer Segments

According to VMware's website, it is not possible to target any specific customer segment for its NSX network virtualization product. It services for enterprises, data center, universities, network service providers. Thus, it was concluded as a mass market.

Value Proposition

VMware's value propositions for its network virtualization are made up of two parts.
One is functional benefit; it includes:

1. Minimizes Risk & Impact of Data Breaches
2. Speeds IT Service Delivery & Time to Market
3. Simplifies Network Traffic Flows
4. Increases Service Availability
5. Improves Negotiation & Buying Leverage
6. Optimizes Use of Network Engineers

The other one is economic benefits; it includes:

1. Micro-Segmentation CapEx Savings
2. IT Automation OpEx Reductions

3. Server Asset Utilization CapEx Savings
4. Price / Performance CapEx Savings
5. Hardware Lifecycle CapEx Savings.

Channels
VMware's product and services are distributed mainly based on their website and local partners. VMware's local partners composes of reseller partner, service partner and technology partner.

Customer Relationships
To serve a mass market. VMware builds up a customer relationship through the following ways — Customer blogs, personal assistance, and self-service. Customer blog is a place where VMware's customers share their stories and learn from each other. Personal assistance is a professional technical assistance service provided by VMware and its partners. VMware also provides many learning materials and webinars to let the customer learn at their own pace.

Revenue Streams
VMware makes money from the following four categories — Product Licensing, Consulting Service and Partner Program. VMware education, where people have to pay and learn VMware products and get certificates.

Key Resources
VMware's key resources are its Intellectual Properties on network virtualization and its product experts both from VMware and its partner companies.

Key Activities
The main activities for VMware are Software Development, Service Provisioning, Product Promotion and Open Source Support.

Key Partners
VMware is a company who focus only on software products, which means it does not provide any real network devices (e.g., Router, Switch). However, VMware has built a strong relationship with its OEM partners, who design and provide hardware and software with VMware technology integrated. Besides OEM partners, VMware also has reselling partner programs, service partner and technology partners, the authors conclude them as SDN partners. Educational institutes are treated as SDN partner as well. Furthermore, VMware is active in many open source projects, for instance, OpenDaylight, OpenComputer, OpenContainers.

Cost Structures
The cost structure is divided into three principal parts for VMware's network virtualization product - Marketing, Open source support and maintaining and developing SDN products.

5.3 BMC of Cisco

Figure 5-3. BMC of Cisco Application Centric Infrastructure (ACI)

Customer segments
Cisco divides its customer segments into four three main categories — Service providers, enterprise, mid-size business and small business. According to Cisco's website, small business does not subsume any SDN-related products or services. The authors combined mid-size business into the enterprise business and added a campus as another customer segment based on the interview with the Cisco expert.

Value Propositions
Although the figure shows a very generic term "SDN value proposition" in this block, there are three value propositions from Cisco's application-centric infrastructure (ACI) — SDN Network, Cloud and DevOps and Security. SDN Network includes Open integration, Simplify operation, and hybrid endpoint support. Cloud and DevOps consist of Policy-aware resource orchestration, real-time governance, and open choice. Security is made up of simplified security tasks and acceleration of application deployment.

Channels
There are essentially two ways to order Cisco products. Order directly from Cisco or order from its partner resellers. There is a product website that offers product descriptions, and customers can use Cisco Direct Ordering Tool to purchase products/services online or call the sales experts for additional assistances. Order from a reseller is as easy as order directly from Cisco, there are numbers of partner and distributors of Cisco in a customer's local area. Customers can use a website[34] to find a local reseller.

Customer Relations

[34] https://tools.cisco.com/WWChannels/LOCATR/openBasicSearch.do

Cisco serves a few ways to maintain a healthy relationship with its clients[35]. Customers can choose to the technical experts for specific questions about Cisco's product or look up in the rich support sources Cisco offers. Smart Net Total Care Services[36] helps solve problems faster, improves operational efficiency, and mitigates the risks of downtime.

Revenue Streams
Cisco's SDN revenue stream composes of four parts. SDN software product, Services & solutions, training and certification, SDN infrastructure and Partner program. By interviewing the expert from Cisco, the authors found out that Cisco is investing heavily in the SDN infrastructure. In other words, they do not want to decouple the SDN controller and network device.

Key Resources
Key resources of Cisco's SDN ecosystem are mainly consists of their intellectual properties and their SDN experts who provide networking services and solutions. Those experts are from Cisco and its solution partners. Also, due to a long time market dominant player, Cisco has maintained a large number of loyalty customers, which are Cisco's another key resources.

Key Activities
The key activities for SDN strategy of Cisco mainly focus on the SDN product development, product promotion, and service provisioning. Cisco also invests a lot in open source project, for instance, OpenDaylight, OpenFlow.

Key Partners
Likewise, to other big companies, Apple, HP, Nike. Cisco outsources its supply chain to other manufacturers so that they can devote more efforts into products development and service provisioning. Besides the OEM partners, Cisco has aligned with many SDN partners for technologies and services. Education institutes are treated as SDN partners as well. Moreover, a partnership with many open source projects and organization makes Cisco stay innovative and keep its influence for the SDN market.

Cost Structure
The cost stream of Cisco's SDN strategy lies in four parts, 1) SDN product marketing, 2) Open source project support, 3) Maintaining and developing SDN software and hardware, 4) the manufacturing cost for SDN infrastructures.

[35] http://www.cisco.com/c/en/us/support/index.html.
[36] http://www.cisco.com/web/services/portfolio/product-technical-support/smart-net-total-care/index.html

5.4 BMC of OpenDaylight

Figure 5-4. BMC of OpenDaylight

Customer Segments
OpenDaylight is an open source project; its product can be downloaded for free by individual and organizations under the Eclipse Public License (EPL-1.0). The customer segments is though a mass market, it focuses more on the cloud/OpenStack networking use cases.

Value Propositions
OpenDaylight platform is a high available, modular, extensible, scalable and multi-protocol SDN controller. In other words, OpenDaylight is a full-SDN solution, which can provide whatever functions a customer needs. As an open source software, OpenDaylight provides their product for everyone at no cost.

Channels
The channel of OpenDaylight is very limited due to its open source characteristics. Customers can get the product on OpenDaylight's website or get it product and services from its project members.

Customer Relationships
OpenDaylight provides a forum[37] to help users and developers to search for answers or ask their questions. It also offers a variety of tutorials for self-learning. As an open source product, developers are allowed for co-creation. They can add features and modify the product themselves under the Eclipse Public License (EPL-1.0)

Revenue Streams
OpenDaylight offers no additional products or services to make a profit at the moment. All the

[37] https://ask.opendaylight.org/questions/

financial supports are from its project members.

Key Resources
Key resources of OpenDaylight consist of the project members and its 466 individual contributors.

Key Activities
The main activities for OpenDaylight are running OpenDaylight Summit, maintaining developer forum, holding Technical work stream (TWS)[38] meetings and Technical steering committee (TSC)[39] meetings.

Key Partners
OpenDaylight's main partners are its project members. Those members are divided into the platinum member, gold member, silver member. Platinum members are the main players, because each platinum member needs to pays 1 million to mainain their 2-year membership status, and are dedicated at least ten developers on the development of OpenDaylight platform.

Cost Structure
The cost structure of OpenDaylight project subsumes three principal parts, 1) maintaining OpenDaylight staff, 2) Holding OpenDaylight Summit, and 3) marketing campaign for OpenDaylight.

A comparison table was proposed for the BMC SDN components, and it was based on the book from Osterwalder and Pigneur (2010). The authors proposed many (important) examples for each BMC block, we have selected the best-fit components for SDN market, and stored them in the comparison table. To eschew biased result in the matrix, several experts were invited to validate the matrix in semi-structured interviews. Eliminated BMC features are either

[38] https://wiki.opendaylight.org/view/Tech_Work_Stream:Main
[39] https://www.opendaylight.org/governance

Table 5-1. Comparison matrix of key BMC components

	HP	Cisco	VMware	OpenDaylight
Front Side				
Customer Relationships				
Personal assistance	Y	Y	Y	N
Dedicated Personal Assistance	Y	Y	Y	N
Self-Service	Y	Y	Y	Y
Automated Services	N	Y	N	N
Communities	Y	Y	Y	Y
Co-creation	Y	N	N	Y
Customer Segments				
Mass Market	NA	N	Y	Y
Niche Market	NA	NA	N	N
Segmented	Y	Y	N	N
Diversified	NA	Y	N	Y
Multi-sided Platform	Y	N	N	N
Channel				
Own channel	Y	Y	Y	Y
Partner channel	Y	Y	Y	Y
Revenue Streams				
Dynamic				
Asset sale	Y	Y	Y	NA
Usage fee	N	N	N	NA
Subscription Fees	Y	Y	N	NA
Brokerage fees	N	N	N	NA
Lending/Renting/Leasing	N	Y	N	NA
Licensing	Y	Y	Y	NA
Advertising	N	N	N	NA
Fixed				
List Price	Y	Y	Y	NA
Product feature dependent	N	N	NA	NA
Customer segment dependent	N	N	N	NA
Volume dependent	N	N	N	NA
Value Proposition				
Performance	Y	Y	Y	NA
Customization	Y	Y	Y	Y
Getting the job done	Y	Y	Y	NA
Brand/status	Y	Y	Y	N
Price	NA	NA	NA	Y
Back Side				
Key Partner				
Strategic alliances between non-competitor	Y	Y	Y	Y
Coopetition: strategic partnerships between competitors	Y	Y	Y	NA
Joint ventures to develop new businesses	Y	Y	Y	N
Buyer-supplier relationships to assure reliable supplies	Y	Y	NA	N
Key Activities				
Production	Y	Y	Y	Y
Problem Solving	Y	Y	Y	N
Platform/Network	Y	N	N	N
Key Resources				
Physical	Y	Y	N	N
Intellectual (brand patents, copyrights, data)	Y	Y	Y	N
Human	Y	Y	Y	N
Cost Structure				
Fixed Costs (salaries, rents, utilities)	Y	Y	Y	Y
Variable costs	Y	Y	Y	Y
Economies of scale	N	Y	N	N
Economies of scope	Y	Y	N	N

The results of the BMC components were calculated in the following tables (Table 5-2 and Table 5-3). The authors firstly divided the business components into nine blocks on the business model canvas consensus. Then, the authors counted the number of "Y" in each block and the total BMC component number. For example, as it is shown in Table 5-2, in the customer relationships block, HP contains five "Y"s, and the total number of the component is 6. Hence, the adoption rate of HP is five divide by 6, which is 83.33%. Following this algorithm, the authors calculated for the other eight blocks for the rest of the organizations. The final results are shown in Table 5-3.

In Figure 5-5, it illustrates the adoption percentage for each organization in each BMC block. In the block Customer Relationships, Cisco and HP have slight higher adoption rate than VMware, and OpenDaylight has the lowest rate. However, four companies achieved the same adoption rate in the Customer Segments block, indicated that there was little variety in customer segments for SDN market. A likewise situation happened to the block Channel as well. In the Revenue Streams block, Cisco ranked the highest, followed by HP, then VMware. OpenDaylight did not have a revenue stream due to its open source software nature. HP and Cisco have achieved the highest rate for Key Partner; VMware reached their three quarter percentage, and OpenDaylight was the lowest. In Key Activities, Cisco has the highest adoption rate when HP and VMware share the same portion, but OpenDaylight achieved the lowest rate. According to the data, OpenDaylight did not comply any of the Key Resources components, but Cisco and HP nailed all the components in this block. VMware was ranked in between. The last but not least, Cost Structure has a various adoption rate from each organization. Cisco reached the highest rate, HP secured its second place, VMware and OpenDaylight are neck to neck but lower than HP.

In conclusion, the more BMC features a company has adopted, the more likely it will stay competitive in the market. However, the adoption rate should be utilized in a situational way. Elango, Fried, Hisrich and Polonchek (1995) stated that in an earlier stage, the investors were interested in the proprietary products, product uniqueness and high growth markets. For instance, if it is a startup company, the most critical BMC component are the value proposition, key resources, revenue stream, and so forth, which are the key elements the investors interested. Elango et al. (1995) also claimed that late-stage investors were more interested in demonstrated market acceptance. In other words, one should take more BMC components into consideration, such as customer relationships, customer segments, channels, partnerships, which are critical to a long-term success of a company.

Table 5-2. Example of customer relationship BMC components results.

Customer Relationships			
	Adoption	Total	Adoption rate
HP	5	6	83.33%
Cisco	5	6	83.33%
VMware	4	6	66.67%
OpenDaylight	3	6	50.00%

Table 5-3. Results of adoption rate of each BMC components.

	Customer Relation-ships	Customer Segments	Channel	Revenue Streams	Value Propos-ition	Key Partner	Key Activities	Key Resources	Cost Structure
HP	83.33%	40.00%	100.00%	36.36%	80%	100.00%	100.00%	100.00%	75.00%
Cisco	83.33%	40.00%	100.00%	45.45%	80%	100.00%	66.67%	100.00%	100.00%
VMware	66.67%	40.00%	100.00%	27.27%	80%	75.00%	66.67%	66.67%	50.00%
OpenDaylight	50.00%	40.00%	100.00%	0.00%	40%	25.00%	33.33%	0.00%	50.00%

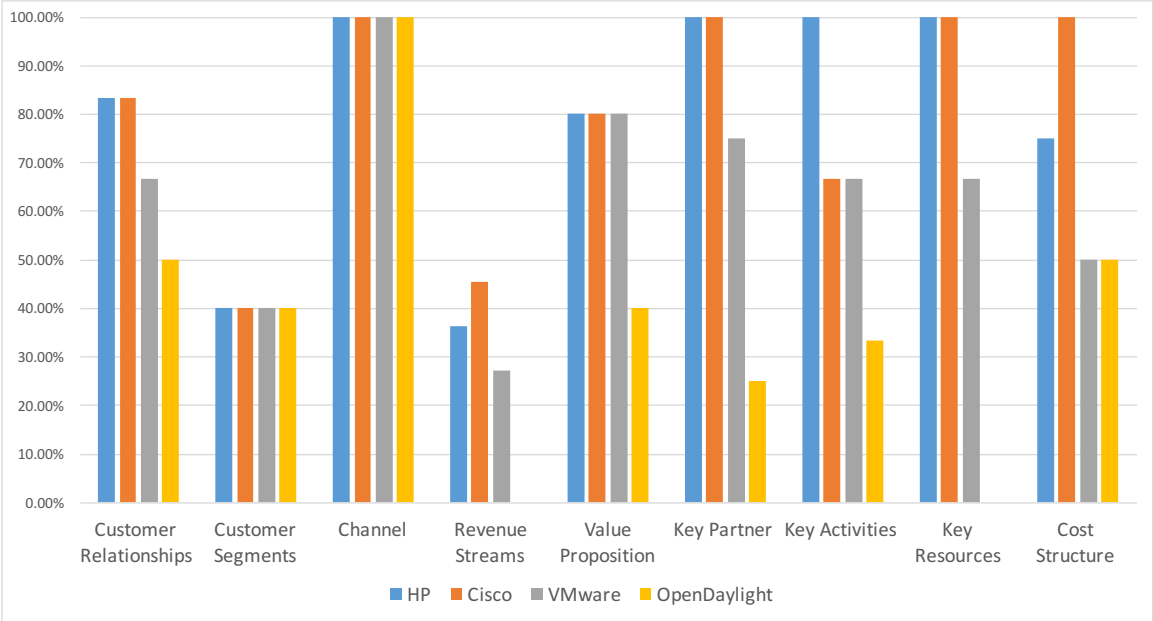

Figure 5-5. Visualized results of the percentage of adoption rate of each BMC components.

Chapter 6 Data Validation on the existing BMC cases

Most of the data in this thesis are collected from the companies' websites and technical documents, and due to the fast growth of the SDN market, a single function of a product could be changed shortly. Therefore, the data validity only lasts until the summer of 2015. In addition, for example, most of the SDN features are based on even older literature reviews, which may become invalid today. Therefore, to ensure the quality of the created business model canvas, one of the solutions is to validate the models with the experts from those organizations.

The person we have interviewed have a strong networking background and are familiar with the SDN concept. However, albeit they are from the correspondent companies, their opinions can only reflect their insights on the business models and SDN features, they can neither represent the companies nor the entire SDN industry. Even though the main purpose of these interviews was to validate the models and data, we still proposed to use a semi-structured interview method (Fylan, 2005) when conducting the interview. The main reason was because there were only a small number of similar studies or papers can be found in the topic of SDN, and most of them were very technical that were lacking a business-centric concept. Therefore, we believe that if we use a semi-structured interview method, there will be a high chance that we can grab more useful information and knowledge from the interviewees. Some example interview questions can be found in Appendix F. Last but not least, we were unable to contact any experts from VMware due to our limited industrial connections, but we expect this to have a limited impact in the results. We will elaborate it in the discussion chapter (Chapter 8).

6.1 Data validation – the HP case

The interview with HP was conducted with two Solution Architect from HP Wireless, Networking & Mobility. They both had rich experiences in the SDN industry and was involved in some HP's latest SDN projects. We went through and discussed the business model canvas, SDN architecture and the comparison matrix generated from the works on HP.

On the one hand, some of the business components in the BMC, such as Dedicated personal assistance, Transformation service & solution, and Open source organizations were suggested to be removed, because they are either sub-set of other business components or the term was not correctly described. On the other hand, the multi-sided customer segment design was highly praised by them. Although, they did not make any money by providing the SDN AppStore to the developers, i.e., developers can sell their product in the SDN application in HP's SDN AppStore in whatever price they wanted and HP will not charge a commission fee on each sale, we both agreed that in a long term, as the volume of SDN APP increased, a platform like this will gain an enormous benefit from its multi-sided customers.

When reviewing the SDN solution model, the interviewees showed some hesitation in answering the questions, because the SDN architecture (Haleplidis, 2014) we use is based on a very academic perspective, which divided the SDN controller into two parts, the controller plane and the management plane. However, according to the HP interviewees, in reality, they put everything into one single component, i.e., the HP VAN controller. There was a mixture of functions for the controller plane and management plane, and it was useless to divide the SDN controller into two part when explaining it to a potential customer.

The SDN quality model was not perfect, and the interviewees emphasized that the SDN features can vary in different situations, even now they cannot satisfy all the requirements in all situations. Also, due to the fast developing of the SDN industry, practical validation of the SDN quality model and solution model can never be guaranteed. In other words, it was hard to apply and validate the model in real business. Therefore, our interviewees praised our method for creating a certain mapping between the business concept and the SDN functions, but the limitations were 1) the SDN functions were not exhaustively included, 2) the model needed a long time of testing (on a company's strategic level) to validate its validity.

6.2 Data validation – Cisco case

The interview with Cisco was with a consulting system engineer from one of the GC data centers. He had many years of experience working in the networking industry and had a strong technical background. Although he was not directly involved in Cisco's SDN project, he remained as a high-quality insights provider due to his long networking career and SDN knowledge from Cisco.

Although the BMC captures most of the business activities for Cisco's SDN solution, in reality, Cisco applies different strategy on different SDN cases. Our interviewee suggested us to create a different business model canvas for each SDN case, which can increase the understandibility to the customers when presenting to them. Similarly, the SDN solution should consider different SDN case as well. However, the concept of modeling the business models, and mapping them to the SDN functions was a new way of working. Our interviewee was expecting a system that can help their customers to easily choose their favor products by themselves, e.g., a customer didn't know which product to choose, the system will ask him/her several questions, and then finally popped up one or several best-fit products/solutions for him/her, which he though was the best practical opportunity for our model.

Furthermore, based on his knowledge of networking and SDN, he believed that it was impossible to map the SDN features into a generic model. Not only Cisco but also the rest of the networking companies, none of them can achieve this at the moment. He helped us go through all the SDN features and QAs, and validated all of them. However, he strongly suggested that some of the features cannot be validated as Yes or No. For example, the SDN feature "Malicious activity detection and mitigation" was one of the key features of Cisco's SDN product. However, it was tough to measure the ability of malicious activity detection in real business case. Even the best system cannot guarantee it can detect all the malicious activities and report them in time. Since SDN was a software-centric concept, he suggested that people can set up a new research on this single topic to create an SDN malicious activity detection degree based on software malicious evaluation. Therefore, taking the Cisco expert's suggestions, we decided to highlight the scope of our SDN features only valid in a very high-level concept, which cannot represent any specific use case in SDN but work as a contribution to the SDN feature library. This part will be further discussed in the limitation part of this paper (See Section 9.2 Limitation).

6.3 Data validation – OpenDaylight case

The validation for OpenDaylight was conducted with an OpenDaylight ambassador, who has over 13 years of working experiences in networking companies like Huawei, Cisco, Juniper and Midokura.

We sent out the models to OpenDaylight expert for review, and then had some discussions over OpenDaylight and open source software in SDN. According to the interviewee, buying an SDN controller or equivalent software was senseless, unless one will gain market share simultaneously, but selling a full SDN solution was a real business. For examples, HP used OpenFlow-based controller as a new control plane for its switches, Cisco -- they had ONE and APIC, and from our interviewee's knowledge, APIC was the one they were pushing hard across their product portfolio even outside of Nexus 3K and 9K switches -- similarly selling the SDN controller with its switch portfolio products; as for VMware, they had a network virtualization solution -- NSX controller was part of the solution. OpenDaylight can be part of a larger solution offered by a company, or it could be used as a component of cloud networking, even in the future, OpenDaylight could go commercial. Accordingly, he highly agreed that we created a business model canvas for OpenDaylight.

Generally, regarding to the business model canvas of OpenDaylight and the SDN quality and solution model, our interviewee held a positive view. On the one side, our interviewee believed the SDN quality model had been well covered by OpenDaylight Lithium, because OpenDaylight was a module based, full SDN solution. However, he believed that the SDN features, as well as the SDN quality attributes were not exhaustive. On the flip side, the original BMC did not completely reflect OpenDaylight's business activities. OpenDaylight did not have a specific customer segment; everyone can download and use its product, it was free of charge. Thus, the customer segment was changed to "Mass market". The value proposition was changed to "Full SDN controller", "module driven" and "Open source software". There were no revenue streams for OpenDaylight because the most important financial contributors were the platinum members. Each of them was on hook for at least two years, $500,000/yr (so $1MM USD each). Since its inception (6 platinum members), OpenDaylight lost two platinum members (IBM, Juniper) and gained four (Dell, Ericsson, HP, Intel). In addition to $1MM financial commitment, platinum members were also supposed to commit ten developers to projects during the period of their platinum status -- Redhat, for example, hired a bunch of people to do that (though since then most of those engineers had gone out to SocketPlane). Key activities were OpenDaylight Summit, Developer forum activities, Technical work stream (TWS) meetings and Technical steering committee (TSC) meetings. Key resources were "Project members" and "Community members/contributors". Key partners were "Platinum members" and "other project members". One of the most interesting parts was the Cost structure of OpenDaylight, our interviewee mentioned that the main cost was spent on the travel expense for its staffs (they travel a lot to attend conferences and events). OpenDaylight annual summit was paid by the board, but it charged the attendees a high fee so that it may break even. Marketing cost was another significant cost for OpenDaylight.

6.4 Data validation summary

To summarize the results of the data validation interviews, we have created a table to compare and spotlight the keywords that claimed by our interviewees.

Table 6-1. Data validation summary table

Case organization	Keywords		
	BMC	SDN quality model	SDN solution model
HP	▪ A few misused terms ▪ Multi-sided customer segment was an interesting, great pattern. ▪ BMC somewhat reflected HP's SDN strategy, but only on a high level.	▪ Not perfect ▪ SDN features is not exhaustive ▪ Hard to evaluate the SDN features	▪ SDN architecture is too academic, hard to understand by end customers.
Cisco	▪ A single BMC cannot capture all the SDN cases in Cisco ▪ Create separate BMC for different SDN cases	▪ Consider different SDN cases ▪ Impossible to map all SDN features into a single model ▪ SDN features are hard to validate ▪ SDN feature test analysis	▪ Inspiring model ▪ Worth further exploring ▪ Create a decision making software
OpenDaylight	▪ ODL has no specific customer segment ▪ Some misused terms ▪ No revenue stream	▪ Believed it well represented most of the features of ODL product ▪ SDN features are not complete	▪ Interesting

Regarding the primary goal of this data validation was to evaluate the data we had collected for the BMCs, it was conducted efficiently and effective. The data were reviewed by experts from each organization and mistakes were corrected. Furthermore, the interviewees provided their own opinions on the SDN quality model and SDN solution model. Majority of them held positive thoughts, but some concerns were proposed as well. For example, the interviewees questioned us whether we had taken different SDN cases into consideration, how can we effectively validate each SDN features, and so forth. Those limitations will be further discussed in Chapter 10.

Chapter 7 SDN case: Huawei Agile Network Solution

In the following sections, the research approach will be applied to the case company Huawei, and created a customized business model canvas for their agile network solution. In Section 7.1, the authors provided a brief introduction about the case company and their problems. The result, i.e., a customized business model canvas will be shown in Section 7.2, and Section 7.3 will explain the evaluation process within the case company.

7.1 Huawei agile network solution

Scholars have proposed that technological change can become market revolutions that incumbent firms must master if they want to survive (King & Tucci, 2002). To catch up with the networking revolution, Huawei has proposed an agile network solution and the carrier-class SDN controller[40]. Huawei agile network solution is the name for Huawei's SDN products and services. However, they do not possess a complete and perfect ecosystem to sustain and improve their SDN service in a long term. For example, they cannot make a decision whether they should develop their Cloud orchestration platform or should go completely for an existing popular open source platform (e.g., OpenStack). In the meantime, their competitors, for instance, HP, have already built up their SDN products and the first industry SDN AppStore ecosystem. Hence, Huawei remains a high uncertainty in developing business of SDN. The main reason, according to the people from Huawei, is the lack of a business model that can capture the entire ecosystem of the SDN. Besides, King and Tucci (2002) indicated that the experiences of an enterprise to respond to a new market are imperfectly understood, i.e., the managers don't have a mature way to tackle with the new technological wave. Similarly, Huawei was eager but lacks this capability to develop their own business model for SDN.

7.2 Customized business model canvas

Based on the process introduced in the previous section, a customized SDN business model canvas (Figure 7-1) is created together with our case company, which will be shown and explained in this section. The canvas will be delineated in two parts, the front end, and the back end. The former illustrated the activities and relationships that a company build for its customers, the latter showed the key activities, resources and partners that help the company sustain the front end business. In Figure 7-1, each business model canvas block was filled with two different colored texts. The blue one is interpreted from the interviews with our case company; the red one is picked up/interpreted from our BMC component library.

[40] http://pr.huawei.com/en/news/hw-310990-sdnsnc.htm#.VpoRRc7m_4E

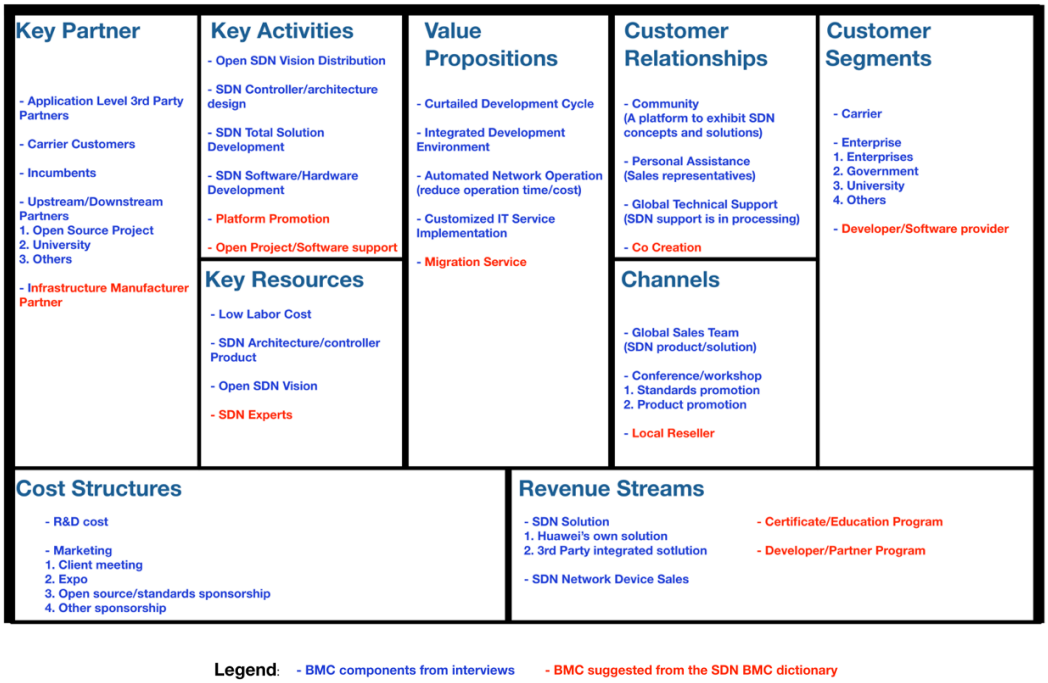

Figure 7-1. Customized SDN business model canvas of Huawei

Front end

Customer segments of Huawei focus on two parts, namely the carriers and the enterprises. Carriers are those big telecommunication providers around the world, e.g., Vodafone, T-Mobile, KPN. The enterprises, however, according to our interviewees, subsumes large and small businesses, governments, universities and other different types of organizations. Regarding networking, there are mainly two business requirements from the carriers, 1) being able to faster build up new IT services and applications. 2) Simplifying the operation and maintaining processes, i.e., mitigate cost and time on the operate and maintaining activities. The other customer segment, enterprises are in needs of 1) a customized campus network to comply their business needs. 2) a data center (for some of the enterprises) that can span easy data migration and other value-added services, such as cloud computing, industrial automation.

The authors inserted a third customer segment: developer/software provider, which was found in our BMC component library and was admitted by our case company after suggested to them. By adding this customer segment, our case company can build up a complete ecosystem for its SDN business. Also, it will add up more revenue streams when to collaborate in a synergic way.

Value proposition is designed to comply the business requirements from the customers. Thus, to correspond the needs mentioned above, Huawei's SDN solution can monitor the networking automatically and discover problems, isolate problems, recalculate network topologies to fix the problem, which can help its customers to mitigate operation and maintaining cost. Huawei also provided an integrated developing environment, where anyone can build, test and run his or her own applications on their networks. As a consequence, it curtails the development cycle, mitigates the configuration time, speeds up the IT services implementation.

However, the authors noticed that Huawei has not put their migration service as their key value proposition. Farias, Salvatti, Cerqueira and Abelém (2012) have proposed a way to manage the legacy network environment by using OpenFlow control plane. They claimed that the compatibility of the legacy network protocols cannot support those new SDN controllers, which means OpenFlow is unable to handle or manage legacy equipment, and as a result, it is tough to connect the OpenFlow environments with legacy network. Additionally, during rollout, there is a practical problem involving legacy switches, because they do not support the OpenFlow protocol and need to be upgraded/re-engineered at a huge cost. Therefore, by offering an easy, costless migration service is the key to acquiring customers in the SDN era. This component is picked up in our BMC component library as well.

Channels serve the ways to deliver the SDN product and value to the customers. Huawei focuses on basically two channels, 1) the traditional global sales team, who is responsible for taking care their local customers around the world. The sales team penetrate the local market and sell their SDN products and solutions. 2) through conferences and workshops around the world, Huawei can promote their standards together with their customers, especially the carriers, so the others have to follow the same standards when collaborating with Huawei and its carrier customers. Product promotion is also a big part of the conferences, exhibition, and workshops. Demos, prototypes will be exposed to potential clients during these types of channels.

The authors added local reseller as a supplement to this block according to our BMC components library. We believe that other SDN providers they are doing so because local reseller is not only a products distributor but also a brand representative, which composes of a healthy ecosystem for the SDN market. Also, a local company has more advantage when getting to the local customers.

Customer relationship of Huawei consists of three parts. A community, where a platform to exhibit the SDN concepts and solutions that are served by Huawei. In this community, people can post their questions, communicate with other users, the SDN experts will answer the questions and keep the interactions with those existing/potential customers. Personal assistance is the same people from the global sales force, where customers can require one to one help desk service. Although Global Technical Support, i.e., Huawei Global Technical Assistance Center/HiCare Support Services[41] has been introduced for a few years, SDN has not become part of the it yet. Nevertheless, Huawei promises to speed up and integrate the SDN support service into the Global Technical Support service.

In addition, we encouraged Huawei to add a co-creation component as an element that corresponds to the Develop/Software provider component in the customer segment block. It indicates that a relationship with the developer and software providers is built, and Huawei truly takes the developers as part of its customer segment.

Hence, the *revenue streams* contain not only the traditional ways of making revenues, such as providing SDN solutions (Huawei's solution or third party integrated solution) and selling SDN network devices, but also providing some services to the developer/software provider side. For

41

http://www.huaweienterpriseusa.com/system/files/resources/Huawei_Enterprise_Hi+Care+Support+Services+Description.pdf?nid=420

instance, based on the BMC component library, we added a certificate/education program and developer/partner program.

Back end

Key resources, as described by our interviewees from Huawei, contains three components. 1) Low labor cost, though the salary increases recently in China, it remains competitive against most of the western countries. Hence, Huawei still places its primary research force in mainland China. 2) SDN architecture/controller product, as a core part of the entire SDN solution, the SDN architecture, needless to say, is Huawei's key resources. Furthermore, the open SDN vision is seen as a critical resource in Huawei's whole SDN strategy, without this vision, all the investments and efforts will probably go in vain.

Nonetheless, the authors suggested Huawei to subsume the SDN expert as its key resources as well. Both to show it to its employees, who are the most valuable assets of the company, also to deliver the messages to its competitors, as well as its customers that Huawei cares about their employees.

Key activities are divided into four different components. 1) Open SDN vision distribution, by promoting its vision and strategy for SDN, Huawei becomes an eye catcher in the SDN market. It is part of the marketing activities. 2) SDN controller/architecture design, this activity will determine whether Huawei can keep its core SDN product competitive in the market. 3) SDN total solution development, this activity brings the advanced networking solutions to comply various customer requirements. 4) SDN software/hardware development, since SDN is an application-centric solution, application development determines the quality of the end services to the customer, and hardware is a part of the profit comes. Thus, both software and hardware design and development play a significant role within Huawei.

Based on the suggestions (adding developer/software provider) for customer segments and customer relationship, Huawei needs to upgrade its integrated development environment into an AppStore like platform, which can better connect the developer/software providers and the customers. Hence, a platform promotion activity is needed in the future. Furthermore, to align with Huawei's open SDN vision, the business model canvas should also contain open project/software support as a core activity in Huawei, by using an embrace and extend strategy, Huawei should be flexible enough to the market change, and staying at the cutting edge of the SDN technology industry.

Key partners consist of four categories. 1) Application level third party partners, according to our interviewee in Huawei, they have a tight collaboration with all the application providers, which makes Huawei's SDN product various. 2) Carrier customers, carriers play an essential role in Huawei's partnership system, because they not only purchase services and products from Huawei but also co-create and push new networking standards to the market together with Huawei. 3) Incumbents, working with competitors is the strategy that Huawei use to explore an emerging market like SDN. By doing so, they can promote new technologies and way of running the businesses faster than working alone. 4) Upstream/Downstream partners, this category subsumes the rest of the partnership. For example, Open source projects, universities.

As though the infrastructure manufacturer partners are part of the upstream/downstream partners, the authors insist that Huawei should separate its suppliers into an independent component because selling hardware is the biggest profit Huawei makes from and according to our BMC component library, other companies all have this element in this block.

Cost structure comprises of two parts. Namely, the research and development cost for SDN and the other is the marketing cost, which subsumes client meetings, attending expos, being members and sponsor for open source project/standards.

7.3 Evaluation

The following sections contain the results of the assessment of our research approach and the customized SDN BMC of the case company. The results of the evaluation in the first sub-section presented the aspects from the business model canvas expert. The second sub-section explained the thoughts from the case company -- an SDN provider.

7.3.1 Modeling method evaluation with business model canvas expert

The aim of the evaluation is to assess the overall acceptance of our research approach, i.e., using business model canvas to analyze existing business models in an innovative IT market. Although it cannot prove whether the final business model canvas is appropriate for the case company or not, it can reflect an overview on the whole method that was to build the final business model canvas. The interview was done with a certified business model canvas coach, who has a formal job as an independent business consultant.

The expert indicated that this research can only solve 50% of the problems for a company because one cannot apply this approach to their business immediately. Business model canvas only provided an overview of the business structure within the organization, and the SDN architecture did not provide a seamlessly mapping with the business model canvas. In other words, the SDN architecture only represented parts of the business model canvas. Therefore, the overall approach was not complete, and the suitability was limited if considering to the whole organization. However, regarding some specific areas, such as SDN service and application development, our approach offers a module-based, effective way of creating a business model in the IT market.

7.3.2 Evaluation with case company

We had interviews with people from different levels of the SDN team. The purpose was to evaluate the research approach and the model we proposed on the perspective of an SDN provider.

General suitability of the method

Regarding the process deliverable diagram in Chapter 2, and the models we created in Chapter 7.2, virtually all interviewees stated that in a booming market like SDN, there was no standard or rule to do the business. They have never seen similar researches in the field of SDN, nor in other IT field. Business model canvas is an effective tool to visualize all the business factors into one canvas. They also mentioned that the business model canvas was useful for team brainstorming during a meeting. Thus, though there was no standard way of evaluating the method we used, they believed it was suitable, and if we apply it appropriately, business model canvas and the SDN technical architecture can help build their theoretical cornerstone of the SDN strategy.

Specifically looking at each step in the research model (Section 2.1), the results are stated below:

An in-depth literature review on the preliminary studies: Our interviewee did not contribute too many suggestions on this part since they are focusing on the practical part of SDN. However, our interviewees also stated that a strong theoretical background is a key to practical success, and it is the limitation within their company.

Modeling existing SDN provider in the market via business model canvas: The idea of analyzing existing SDN providers is praised by our interviewees, because, as a company, it is hard for them to collect unbiased information from their competitors. Besides, our interviewees believe it is a good strategy to start analyzing some existing products before create one's own business model. Particularly in an un-mature field, reusing the current resources for innovation is considered as a thoughtful approach. Business model canvas is a new method to our interviewees, as they have stated above, they would like to see those new methods to be applied in the innovative IT market, but cannot judge whether it is appropriate in their business.

New business model canvas creation process: A majority of the interviewees stated that the assembly-based method of creating new business model canvas provides a scientific way of reusing business model components and creating customized business models. Some of the interviewees from a managerial level declare that they are not interested in the creation model, but more on the deliverables created by this creation process.

Evaluation process: Our interviewees raised their concerns that the research is not data – driven, thus, it is hard to present precise evaluation results. Besides, the interviewees suggested that a more explicit evaluation should be proposed. Therefore, based on the book "business model generation" (Osterwalder & Pignuer, 2010), a SWOT (strength, weakness, opportunity and threat) analysis was applied, the results were shown below, and the template can be found in the appendix:

SWOT evaluation of the business model canvas

The detailed steps and design of the SWOT evaluation process can be found in Appendix F. Although the evaluation questions do not have any SDN related words, it was designed to validate the SDN BMC of the case company. The evaluation form was sent to the manager and several senior engineers in the SDN department of the case company to collect their views on the quality of the business model canvas in Section 7.2. This evaluation contains two primary values. On one hand, the results will present the current quality of the business model, especially by spotlighting the key fields that require more attentions. On the other hand, the evaluation scores serve as a benchmark for future business model evaluation comparison. Firstly, we will present the final results in Figure 7-2, then follows with the descriptions of the evaluation process. At last, a brief summary will be provided.

We have mapped the SWOT evaluation scores into the business model canvas to better illustrate the quality and status of the business model canvas (Figure 7-2). Using this business model canvas evaluation score map, we can straightforwardly spotlight the main weaknesses of Huawei

are the cost structure and customer segment, also, key partner, key activities and key resources are relatively lower than other blocks.

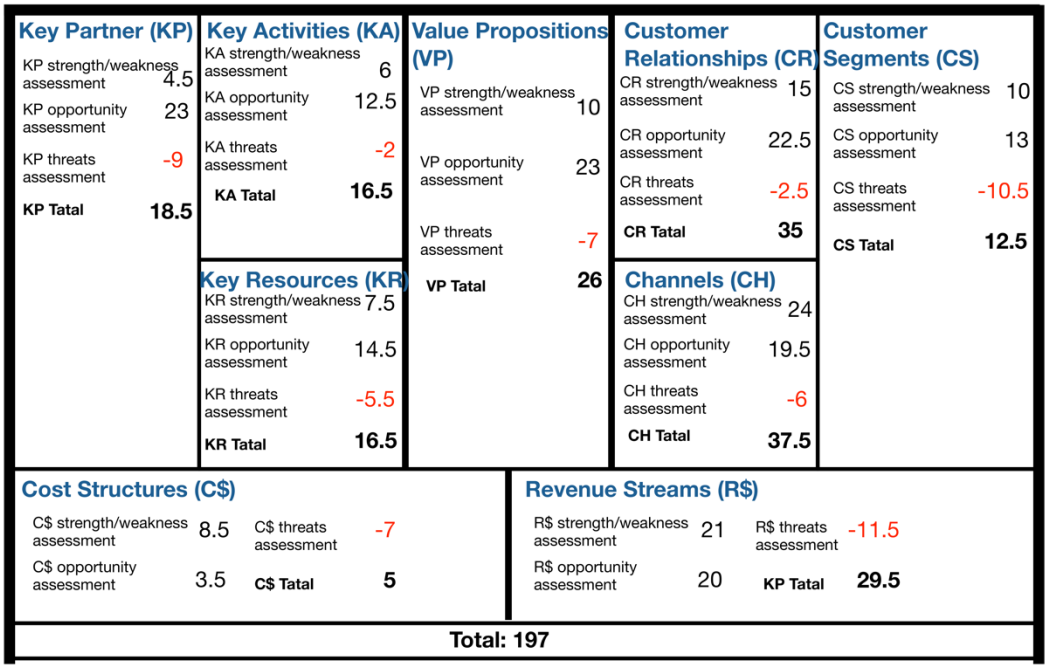

Figure 7-2. Business model canvas SWOT evaluation mapping

We categorized SWOT evaluation into three categories. 1) Strength/Weakness, 2) Opportunity, 3) Threats. Based on the book "business model generation" (Osterwalder & Pigneur, 2010), in Strength/Weakness, 78 relevant questions were proposed. Half of the question are to evaluate strength, and half is designed to assess the weakness, e.g., question to evaluate the strength: "Our value propositions are well aligned with customer needs", question to evaluate the weakness: "Our value propositions and customer needs are misaligned." In the second category of opportunity, 37 questions were created, and there were 21 questions in the third category of threat. Each question has a score range of ±1 to ±5, 4 and 5 represented the high impact, 1 and 2 stood for the low impact, and 3 was the normal impact. Exception for the combination table of Strength/Weakness in Appendix F, because it only showed the 39 questions, which had been calculated (The score of Strength plus the score of Weakness). Thus, the positive number was strength, the negative number was weakness, zero meant no strength or weakness. Questions of strength and opportunity were set to positive and questions of weakness and threat were set to negative. Furthermore, each category was divided into four sub-categories, which were offer, finance, Infrastructure and customer. The nine blocks in business model canvas were subsumed in each group. Table 7-1 provided an example of the threat evaluation below; complete data can be found in Appendix F.

Table 7-1. Example data entry of threat evaluation

Threats		
Subject	Score	Result
Offer		
Are substitute products and services available?	3.5	High
Finance		
Are our margins threatened by competitors? By technology?	4	High
Infrastructure		
Could we face a disruption in the supply of certain resources?	3	Normal
Customer		
Could our market be saturated soon?	1.5	Low

To better present the evaluation results, we visualized the data into the following figures. In Figure 7-3, it represents the strength/weakness on the nine business model canvas blocks. In the block of revenue and channel, we found a high strength for Huawei, but it showed an uncertain status in the relation with key partners. Opportunities lay in many business blocks, such as value proposition, revenue, key resource, key partner, and customer relationship. Looking at the threat results, Huawei had a high risk of revenue, key partner and customer segment. Therefore, we can conclude that there are a lot of opportunities in most of the business areas for Huawei, but they should ponder on the revenue, key partner, customer segment, and channel. Besides, we suggest Huawei invest more in constructing a better relationship with its partners. Figure 7-4, focusing on the four categories, summarized the SWOT evaluation in a higher-level that indicated the performance of Huawei in certain areas. For example, infrastructure and customer had a higher opportunity than in the offer (e.g., value and product) and finance (revenue and cost). Regarding the strength, it revealed that Huawei was satisfied with its customer relations than the rest of the three. Accordingly, we believed that Huawei should invest more in the infrastructure and customer while pay more attention to increasing its strength in product/service and business strategies.

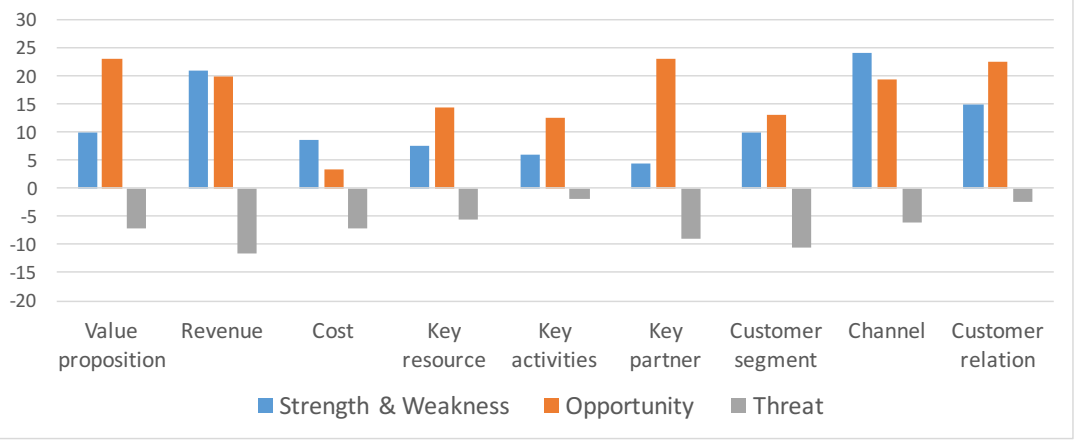

Figure 7-3. SWOT evaluation in nine business model canvas blocks.

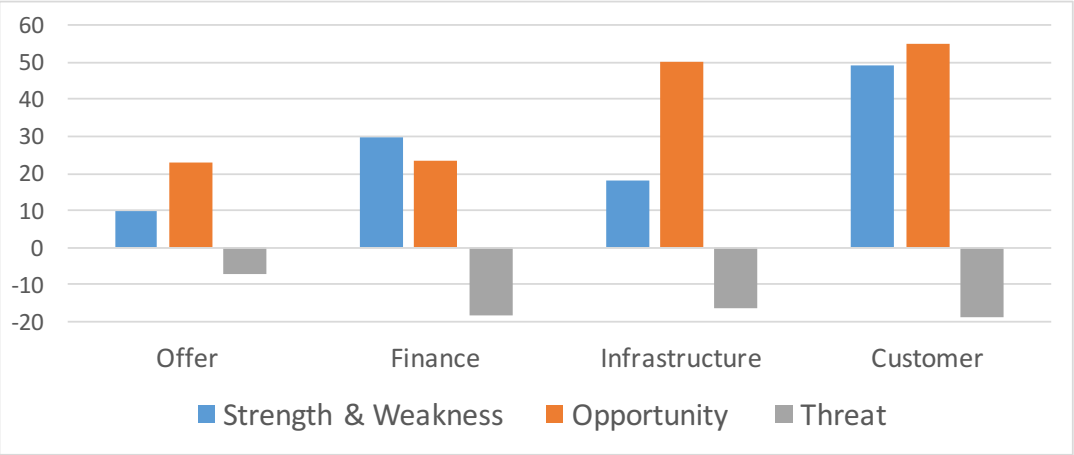

Figure 7-4. SWOT evaluation on four categories

To summarize, the evaluation consists of two parts. One is the general research method evaluation, and the other is the business model canvas SWOT evaluation. The former one, evaluated by the experts, indicated that it was effective and efficient to use business model canvas to analyze the existing SDN providers in the market, and then compare and reuse the business model components when creating a new business model canvas. The latter, SWOT evaluation, provided a quick understanding of the status of each business model canvas block and indicated several critical parts that the case company should pay more attentions. Both results provided strong evidences that our research approach and the business model canvas was of great benefit to the case company.

Chapter 8 Discussion

In this Chapter, it extends the research questions and deliverable table (Table 2-1) by listing and explaining each deliverable and match them to the research questions. Furthermore, in the second sub-section, it describes the contributions of our deliverables and the contribution of the thorough research. The limitations of the thesis will be discussed in the third sub-section.

8.1 Deliverables

The deliverables are divided into two categories to match the two sub-research questions according to Table 2-1, and each deliverable will be explained as follows.

Sub research question 1: What is the suitable method to help market entrants create business models?

According to Levinthal (1990), the ability of a firm to realize the benefits of new, external knowledge, accept it, and apply it to commercial ends is depending very much on the prior pertinent knowledge the firm has. Thus, the suitable method to create a new business model for SDN is to analyze the existing SDN providers on the market. The deliverables are shown below:

1 SDN provider network
SDN provider network (Figure 4-2) illustrates a partner relationship between several key SDN providers in the market. There are nineteen key companies, picked from the market landscape report from ESG (2013), and four open source projects are included as well. We looked up all the official data of partnership for each organization and visualized the relationship via the data visualization tool – Gephi. The SDN provider network provides us with a visual network of the existing provider network, which helps us select the best suit analytical context.

2 Main SDN market player
We selected four SDN organizations (Table 4-7) as our analytical context. The four organizations (Cisco, HP, VMware, OpenDaylight) can represent the mainstream SDN product and solution on today's SDN market.

3 SDN open source organization
Due to the fact that SDN is a new concept, though, there are many open source projects on the market, only a few of them are appropriate to analyze. We only subsume OpenDaylight, because it was founded in 2013, and has been the most fast growing open project in the SDN world, which has reached over 50 members and offered eleven major releases sine February 2014. We believe OpenDaylight can represent, at least most of the SDN open source market.

Sub research question 2: How to build up relations between the business model and the innovative IT market?

We use the quality attribute as a link to join the business model and SDN architecture. Standing on the software engineering's perspective, quality attribute, more specifically, ISO 25010[42], known as the product quality model, is proved appropriate when identifying software and system design objectives. In our case, it assisted the SDN architecture to provide a foundation for SDN application and service design.

1 SDN quality model

[42] http://www.iso.org/iso/catalogue_detail.htm?csnumber=35733

Based on the product quality model (ISO 25010), we created this SDN quality model. Specifically dividing the quality attributes into fourteen categories, which subsume the original attributes from the ISO 25010, and the SDN specific quality attributes referencing to literatures. Moreover, we mapped the quality attributes with thirty SDN features.

2 SDN feature Dictionary
SDN feature Dictionary contains all the essential SDN features, such supportability, programmability, functionality, which can be reused in future studies. The feature library is not complete and need to be updated constantly.

3 SDN solution model
This is the core model to answer the fourth sub research question because it illustrates a high-level business model and technical architecture that can be applied in commercial ends in a company. However, we cannot cover all the business blocks in business model canvas, the focus in our thesis only fills the gap between the business requirements gathering and software designing/development. Other blocks in business model canvas, such as revenue streams, cost structure, key partners, should be covered by other means in the future studies.

Furthermore, to summarize our deliverables, we, therefore, brought forth a vision for SDN. Based on its fast-growing, flexible, application-centric nature, and the module-based SDN solution model, we conclude the SDN vision as follows:

"The ability to provide an application-centric, programmable, modular, and open networking solution."

8.2 Contributions

In this section, it depicted the contributions of the deliverables that were introduced in the previous sections. Note that though every deliverable has its contribution, it only focus on the ones that create significant impacts and contributions to the scientific world.

In regard to the research deliverables, the most noteworthy discovery is the use of business model canvas on modeling and designing business model for the SDN market. Business model canvas was initially conceived as a modeling tool for people to brainstorm, especially for startups to create their business strategies for a new market. In this thesis, we applied and validated the suitability of business model canvas in a new way, proved that this modular tool was effective and efficient in modeling and designing business models in an innovative IT market. Moreover, looking at the SDN architecture, we proposed a unified model, which combined the business model canvas, SDN architecture and quality model (Lochmann & Goeb, 2011) into one solution model. Although the solution model lacked the SDN features and SDN quality attributes due to the limited research time, it proposed an industry-first theoretical concept to combine the business model with the technical architecture for SDN solution/product's design and development. Last but not least, the overall research approach also delineated an appropriate way of conducting similar research for the future.

8.3 Limitation

Three major research limitations are noteworthy and need to be aware when reviewing the models and results.

The data collection phase, mainly in Chapter 4, Chapter 5, are not exhaustive. Due to the fast growing nature of the SDN market, every company is proposing new products, new services in every single day. The technical documents and websites contents we have reviewed will be updated rapidly. For example, the organizations we selected in Chapter 4 may not exist in the future, the SDN architecture (Chapter 5) may differ over time, and the business model canvas dictionary may not well represent the company in the future. We as though have not conducted a scientific way of collecting our research data; however, this cannot be avoided due to the nature of a booming new technology. Also, we were not able to interview any VMware experts to review the data collected for VMware NSX, thus, compared to other data, it lacks a human expert check. Nevertheless, as we have claimed, the fast changing SDN market itself cannot provide a static data for analysis either. Therefore, we believe this will not affect the quality of our research heavily.

The other limitation is the SDN features, i.e., the SDN quality model we proposed in Chapter 5. Following the model of ISO 25010, the quality model for software quality, we added several SDN specialized quality attributes in our SDN quality model, which were mentioned in some of the prior researches but have not been widely accepted. Moreover, the SDN features we concluded were not complete because networking industry is a complicated field, which is hard to measure and map. To quote one of our interviewees, “There is no possible way to model all the SDN features in the market, because networking service is a very case-based business.” In other words, no matter how comprehensive the quality model is, it still can not serve all the business cases due to the complexity of the networking situations. Similar suggestions from other experts’ interviews as well, they stated that they were providing SDN services in specific ways. For instance, when deploying a network, they should take the enterprise scale, computing power requirements, the number of users, office size, and even local government’s regulation into consideration. An efficiency and effective monitoring solution in an IT company may not work for a bank, because banks require a higher degree of security than a regular IT company. To summarize, there is little possibility in the networking industry that one single model can solve all the problems, thus, our SDN quality model can only be utilized as a module method to leverage and improve the redesign works in different use cases.

In this thesis, the SDN quality model and SDN solution model were introduced in Chapter 6. However, the authors did not apply those two models into the case study, and there was no evaluation or validation has been done for these two models. Furthermore, the SDN solution model only provided an example to describe the mechanism of the model, but did not elaborate the instructions to utilize and apply it to other cases. The lack of details of those two models may raise confusions and decrease the quality of the thesis. However, due to the mian purpose of this thesis was to explore new business models for software defined networking, the research did not dig into the SDN architecture, SDN quality model or SDN solution model. Those side deliverables did not reveal their values at this thesis; however, they had showed a strong inspiration and promising direction for the future researches. During the expert reviews, the majority of the interviewees had showed their interests and favorable opinion of those potential models for SDN, which will be further introduced in Section 9.3.

The last but not least limitation is the expert interview phase. Although we have talked to many people from well-known industry organizations, the number of people we have interviewed is

limited. Thus, we lacked a significant number to support the results. Furthermore, mentioned by our case company, our results were based on experts' opinions, which has not been approved scientifically or empirically due to the young age of the SDN industry.

Chapter 9 Conclusion

The following sections summarize the final conclusion, and the indications for the future research. Specifically, this chapter introduces a research summary that concludes an overview of the entire research story, and lastly, puts forward some opportunities for future researches and authors' vision for SDN business model.

9.1 Research summary

In this thesis, we proposed to utilize business model canvas as a method to model the existing SDN providers in the market and sums up an SDN quality model to capture the essential SDN features. The business model canvases of the selected organizations were compared and validated by interviewing experts in certain fields, and their business components were stored in a dictionary for reusing in creating a new business model for the case company. Moreover, based on the SDN quality model and business model canvas, we proposed an industry-first SDN solution model that combined the business model with the technical architecture via a unified quality model. As a consequence, the business model canvas was proved to be efficiency on analyzing an innovative IT market, which, in our case is software defined networking. Furthermore, connected the business concept and the technical concept, the SDN solution model provided a holistic view on the entire SDN business ecosystem.

9.2 Future research

Throughout the method design, data collection, modeling and interviewing phases, it revealed many potential opportunities for future researches. The recommendations listed in this section are divided into two parts. One is for the business model canvas, from a business model perspective, and the other focuses on the software defined networking side. Both parts of opportunities are based on the limitations we have confronted, and the suggestions during the expert reviews, and so forth.

Business models

Regarding the business model, especially for the business model canvas methodology, there are tons of opportunities for future studies. After we have done the literature review in Chapter 3, it turned out that there was relatively a small number of researches have been done on the business model canvas in an IT field. To validate the efficiency and effectiveness of business model canvas, more use cases are needed. Due to the modular based nature, the business model canvas can be adjusted to apply in more situations and product analysis. Moreover, there are opportunities lay in the evaluation methods to validate the business model canvas as well. For example, we used SWOT analysis to analyze the strength, weakness, opportunities and threats of the model. However, it sometimes confused our interviewees of the questions in the SWOT analysis form, because the model has not been applied yet to commercial ends, so they can not easily judge it.

Furthermore, there is a sister model of business model canvas called value proposition canvas. It expends the value proposition and customer segment blocks of the original business model canvas. Thus, it can zoom in the critical needs of its customers as well as the values and products that a company can serve its customers. For example, one opportunity could be a re-design/upgrade of the SDN solution model. Since the quality model can not explain all the business model canvas blocks, it is wiser to use value proposition canvas than the business model

canvas. From a value proposition perspective, one may provide a holistic analysis of the business requirements and map them to the quality attributes.

Software defined networking

Focusing on a business model scope, this paper provided an in-depth view of how to design and develop business models for SDN. However, a fast growing market like SDN needs wider attentions in the future. Suggesting by the business model canvas expert, the business model analysis should not only focus on the quality model or SDN architecture part but also needs to cover the whole SDN eco-system to make the deliverables valuable to the commercial ends. A full SDN eco-system may inspire researches on the topics of SDN revenue chain, SDN provider network analysis (e.g., to extend the SDN provider network in Section 4.3), Open SDN system collaboration, innovation and so on so forth.

In addition, from a technical point of view, future researches can dive to analyze the SDN features to provide an explicit list of critical features or functions an SDN product must have. For example, suggested by one of our interviewees, it is worth doing a research on how to rank the capabilities of the SDN features, such as malicious activities detection & mitigation, i.e., to what extent or level can an SDN product fulfill that function. In other words, SDN network capability testing may become another fruitful business in the future.

References

Alt, R., & Zimmermann, H. D. (2001). Introduction to special section-business models. *Electronic Markets-The International Journal*, *11*(1), 1019-6781.

Abd Aziz, S., Fitzsimmons, J. R., & Douglas, E. J. (2008). Clarifying the business model construct.

Burkhart, T., Krumeich, J., Werth, D., & Loos, P. (2011). Analyzing the business model concept—a comprehensive classification of literature.

Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity* (Vol. 1). MIT press.

Bass, L., Clements, P., & Kazman, R. (2012). Software Architecture in Practice.

Brinkkemper, S., Saeki, M., & Harmsen, F. (1999) "Meta-modelling based assembly techniques for situational method engineering," *Information Systems*, vol. 24, no. 3, pp. 209–228.

Chesbrough, H. (2010). Business model innovation: opportunities and barriers. *Long range planning*, *43*(2), 354-363.

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin- off companies. *Industrial and corporate change*, *11*(3), 529-555.

Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & leadership*, *35*(6), 12-17.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative science quarterly*, 128-152.

Cisco System Inc. Credit Rating. (2013, December 16). Retrieved December 16, 2015, from http://www.standardandpoors.com/en_US/web/guest/ratings/entity/-/org-details/sectorCode/CORP/entityId/130285

Campbell, A. T., Katzela, I., Miki, K., & Vicente, J. (1999). Open signaling for ATM, internet and mobile networks (OPENSIG'98). *ACM SIGCOMM Computer Communication Review*, *29*(1), 97-108.

Cisco. (2015). Retrieved July 31, 2015, from http://www.cisco.com/c/dam/en/us/solutions/collateral/data-center-virtualization/application-centric-infrastructure/sdnfordummies.pdf

Chesbrough, H. W. (2006). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

ESG SDN Market Landscape Report. (2013). Retrieved January 16, 2016, from https://www.sdxcentral.com/esg-sdn-market-landscape/

Elango, B., Fried, V. H., Hisrich, R. D., & Polonchek, A. (1995). How venture capital firms differ. *Journal of Business Venturing*, *10*(2), 157-179.

Foukas, X., Marina, M. K., & Kontovasilis, K. (2014). Software Defined Networking Concepts.

Farias, F. N., Salvatti, J. J., Cerqueira, E. C., & Abelém, A. J. (2012, April). A proposal management of the legacy network environment using OpenFlow control plane. In *Network Operations and Management Symposium (NOMS), 2012 IEEE* (pp. 1143-1150). IEEE.

Gordijn, J., & Akkermans, H. (2001). Designing and evaluating e-business models. *IEEE intelligent Systems*, (4), 11-17.

HP virtual application networks SDN controller. (2013). Retrieved January 16, 2016, from http://h17007.www1.hp.com/docs/networking/solutions/sdn/4AA4-8807ENW.PDF

Hedman, J., & Kalling, T. (2003). The business model concept: theoretical underpinnings and empirical illustrations. *European Journal of Information Systems*, *12*(1), 49-59.

Haleplidis, E., Denazis, S., Pentikousis, K., Salim, J. H., Meyer, D., & Koufopavlou, O. (2014). SDN layers and architecture terminology. *Internet Engineering Task Force, Internet Draft, Aug*.

Hewlett Packard Enterprise Co. Credit Rating. (2015, September 23). Retrieved December 16, 2015, from http://www.standardandpoors.com/en_US/web/guest/ratings/entity/-/org-details/sectorCode/CORP/entityId/572190

Huang, D. Y., Yocum, K., & Snoeren, A. C. (2013, August). High-fidelity switch models for software-defined network emulation. In *Proceedings of the second ACM SIGCOMM workshop on Hot topics in software defined networking* (pp. 43-48). ACM.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard business review*, *86*(12), 57-68.

Jonkers, H., Lankhorst, M. M., ter Doest, H. W., Arbab, F., Bosma, H., & Wieringa, R. J. (2006). Enterprise architecture: Management tool and blueprint for the organisation. *Information Systems Frontiers*, *8*(2), 63-66.

Jarschel, M., Zinner, T., Hoßfeld, T., Tran-Gia, P., & Kellerer, W. (2014). Interfaces, attributes, and use cases: A compass for SDN. *Communications Magazine, IEEE*, *52*(6), 210-217.

Kim, H., & Feamster, N. (2013). Improving network management with software defined networking. *Communications Magazine, IEEE*, *51*(2), 114-119.

Khadka, R., Reijnders, G., Saeidi, A., Jansen, S., & Hage, J. (2011, September). A method engineering based legacy to SOA migration method. In *Software Maintenance (ICSM), 2011 27th IEEE International Conference on* (pp. 163-172). IEEE.

King, A. A., & Tucci, C. L. (2002). Incumbent entry into new market niches: The role of experience and managerial choice in the creation of dynamic capabilities. *Management science*, *48*(2), 171-186.

Lochmann, K., & Goeb, A. (2011, September). A unifying model for software quality. In *Proceedings of the 8th international workshop on Software quality* (pp. 3-10). ACM.

McKeown, N. (2009). Software-defined networking. *INFOCOM keynote talk*, *17*(2), 30-32.

Mahadevan, B. (2000). Business models for Internet-based e-commerce. *California management review*, *42*(4), 55-69.

Muhtaroglu, F., Demir, S., Obali, M., & Girgin, C. (2013, October). Business model canvas perspective on big data applications. In *Big Data, 2013 IEEE International Conference on* (pp. 32-37). IEEE.

Morris, M., Schindehutte, M., & Allen, J. (2005). The entrepreneur's business model: toward a unified perspective. *Journal of business research*, *58*(6), 726-735.

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.

McDavid, D. (2003). The business-IT gap: A key challenge. *IBM Research Memo, http://www. almaden. ibm. com/coevolution/pdf/mcdavid. pdf*.

Osterwalder, A. (2004). The business model ontology: A proposition in a design science approach.

Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the association for Information Systems*, *16*(1), 1.

Osterwalder & Pigneur (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons.

Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A. (2015). *Value Proposition Design: How to Create Products and Services Customers Want*. John Wiley & Sons.

Petrovic, O., Kittl, C., & Teksten, R. D. (2001). Developing business models for ebusiness. *Available at SSRN 1658505*.

Rappa, M. (2001). Managing the digital enterprise-Business models on the Web.

Ralyté, J., Deneckère, R., & Rolland, C. (2003, January). Towards a generic model for situational method engineering. In *Advanced Information Systems Engineering* (pp. 95-110). Springer Berlin Heidelberg.

Rosenberg, N. (1997). Uncertainty and technological change. In *The Mosaic of Economic Growth*.

Riebisch, M. (2003). Towards a more precise definition of feature models. *Modelling Variability for Object-Oriented Product Lines*, 64-76.

Spence, A. M. (1979). Investment strategy and growth in a new market. *The Bell Journal of Economics*, 1-19.

Sood, A., James, G. M., Tellis, G. J., & Zhu, J. (2012). Predicting the path of technological innovation: SAW vs. Moore, bass, gompertz, and kryder. *Marketing Science*, *31*(6), 964-979.

Sinfield, J. V., Calder, E., McConnell, B., & Colson, S. (2011). How to identify new business models.

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. *Business horizons*, *48*(3), 199-207.

Scott-Hayward, S., Kane, C., & Sezer, S. (2014, October). OperationCheckpoint: SDN Application Control. In *Network Protocols (ICNP), 2014 IEEE 22nd International Conference on* (pp. 618-623). IEEE.

Timmers, P. (1998). Business models for electronic markets. *Electronic markets*, *8*(2), 3-8.

Teece, D. J. (2010). Business models, business strategy and innovation. *Long range planning*, *43*(2), 172-194.

Voellmy, A., & Wang, J. (2012, August). Scalable software defined network controllers. In *Proceedings of the ACM SIGCOMM 2012 conference on Applications, technologies, architectures, and protocols for computer communication* (pp. 289-290). ACM.

Von Hippie, E. (1988). The sources of innovation. McKinsey Quarterly, 72-93.

van de Weerd, I., & Brinkkemper, S. (2008) *Handbook of Research on Modern Systems Analysis and Design Technologies and Applications*. Idea Global Publishing, 2008, ch. Meta-modeling for situational analysis and design methods, pp. 38–58.

Van de Weerd, I., Brinkkemper, S., Nieuwenhuis, R., Versendaal, J., & Bijlsma, L. (2006, September). Towards a reference framework for software product management. In *Requirements Engineering, 14th IEEE International Conference* (pp. 319-322). IEEE.

van de Weerd, I., & Brinkkemper, S. (2008). Meta-modeling for situational analysis and design methods. *Handbook of research on modern systems analysis and design technologies and applications*, *35*.
Brinkkemper, S., Saeki, M., & Harmsen, F. (1999). Meta-modelling based assembly techniques for situational method engineering. *Information Systems*, *24*(3), 209-228.

Weill, P., & Vitale, M. (2002). What IT infrastructure capabilities are needed to implement e-business models. *MIS quarterly Executive*, *1*(1), 17-34.

Weill, P., Malone, T. W., and Apel, T. G. (2011). "The Business Models Investors Prefer," MIT Sloan Management Review (52:4), pp. 16-19.

Zolnowski, A., Weiß, C., & Bohmann, T. (2014). Representing Service Business Models with the Service Business Model Canvas--The Case of a Mobile Payment Service in the Retail Industry. In *System Sciences (HICSS), 2014 47th Hawaii International Conference on* (pp. 718-727). IEEE.

Zott, C., Amit, R., & Massa, L. (2011). The business model: recent developments and future research. *Journal of management*, *37*(4), 1019-1042.

Appendix

Appendix A. Systematic literature review

Table 0-1. Systematic literature review – word combination

COMBINATION ID	WORD COMBINATION
1	software defined network
2	software defined network architecture
3	software defined network application
4	software defined network controller
5	Networking
6	Programmable network
7	openflow
8	business model canvas
9	business model
10	business model for IT
11	business model and information technology
12	Business process
13	quality attribute
14	change management
15	business quality attribute
16	business IT gap
17	enterprise architecture
18	Software architecture
19	Market entrance
20	Innovation technology
21	Business modeling

Table 0-2. Systematic literature review-screen process

KEY WORD ID	GOOGLE SCHOLAR	ACCEPT BY ABSTRACT	ACCEPT BY CONTENT	TITLE
19	Y	Y	Y	Incumbent entry into new market niches
1	Y	Y	Y	Ending The Confusion Around Software Defined Networking (SDN)
10	Y	Y	Y	Predicting the path of technological innovation
10	Y	Y	Y	Uncertainty and technological change
9	Y	Y	Y	Introduction to special section-business models
9	Y	Y	Y	Business model innovation: opportunities and barriers. Long range planning
9	Y	Y	Y	The role of the business model in capturing value from innovation
9	Y	Y	Y	Business model innovation: it is not just about technology anymore
10	Y	Y	Y	Business models for Internet-based e-commerce

8	Y	Y	Y	Business model generation: a handbook for visionaries, game changers, and challengers
9	Y	Y	N	The utility business model and the future of computing services
9	Y	Y	Y	The business model: recent developments and future research
9	Y	Y	Y	Business models for electronic markets
10	Y	Y	Y	Designing and evaluating e-business models
9	Y	Y	N	Reinventing your business model
9	Y	Y	Y	Developing business models for ebusiness
9	Y	Y	Y	Introduction to special section-business models
9	Y	Y	Y	The entrepreneur's business model: toward a unified perspective
10	Y	Y	Y	Designing and evaluating e-business models
9	Y	Y	N	Business model evolution: in search of dynamic consistency
10	Y	Y	Y	Managing the digital enterprise-Business models on the Web
10	Y	Y	Y	What IT infrastructure capabilities are needed to implement e- business models
10	Y	Y	Y	Business model canvas perspective on big data applications
9	Y	Y	Y	The business model concept: theoretical underpinnings and empirical illustrations
9	Y	Y	Y	Business models, business strategy and innovation
9	Y	Y	Y	Introduction to special section- business models
9	Y	Y	Y	Clarifying business models: Origins, present, and future of the concept
9	Y	Y	Y	Clarifying the business model construct
8	Y	Y	Y	The Business Models Investors Prefer
21	Y	Y	Y	How to identify new business models
9	Y	Y	Y	The power of business models
8	Y	Y	Y	Representing Service Business Models with the Service Business Model Canvas

19	Y	Y	Y	Investment strategy and growth in a new market
1	Y	Y	Y	Interfaces, attributes, and use cases: A compass for SDN
1	Y	Y	N	Extending software defined network principles to include optical transport
1	Y	Y	Y	Scalable software defined network controllers
1	Y	Y	Y	Improving network management with software defined networking
1	Y	Y	Y	High-fidelity switch models for software-defined network emulation
1	Y	Y	N	A network in a laptop: rapid prototyping for software-defined networks
1	Y	Y	Y	Software-defined networking
1	Y	Y	Y	Software Defined Networking Concepts.
1	Y	N		Where is the debugger for my software-defined network?
1	Y	Y	Y	Open signaling for ATM, internet and mobile networks
5	Y	Y	Y	A survey of active network research
1	Y	Y	N	B4: experience with a globally-deployed software defined wan
6	Y	Y	Y	Building programmable wireless networks
1	Y	Y	Y	The road to SDN
1	Y	Y	Y	Software Defined Networking (Dagstuhl Seminar 12363)
16	Y	Y	Y	The business-IT gap: A key challenge
1	Y	Y	N	Are we ready for SDN? Implementation challenges for software-defined networks
17	Y	Y	Y	Enterprise architecture: Management tool and blueprint for the organization
1	Y	Y	N	Software-defined optical networks technology and infrastructure
14	Y	Y	Y	Leading change: Why transformation efforts fail
13	Y	Y	N	Quality attribute design primitives
1	Y	Y	N	On scalability of software-defined networking

13	Y	Y	Y	Software Architecture in Practice
1	Y	N		Logically centralized?: state distribution trade-offs in software defined networks
13	Y	Y	Y	Quality-attribute based economic valuation of architectural patterns
13	Y	Y	N	The importance of origin as a quality attribute for beef: results from a Scottish consumer survey
1	Y	N		Revisiting routing control platforms with the eyes and muscles of software-defined networking
20	Y	Y	Y	Open innovation: The new imperative for creating and profiting from technology
20	Y	Y	Y	The sources of innovation
2	Y	Y	Y	SDN layers and architecture terminology
4	Y	Y	Y	Ten Things to Look for in an SDN Controller
3	Y	Y	Y	OperationCheckpoint: SDN Application Control
7	Y	Y	Y	OpenFlow: enabling innovation in campus networks
7	Y	N		Openflow random host mutation: transparent moving target defense using software defined networking
7	Y	Y	Y	A Proposal Management of The Legacy Network Environment using OpenFlow Control Plane
1	Y	Y	N	A Survey of Software-Defined Networking: Past, Present, and Future of Programmable Networks
18	Y	Y	Y	Towards a reference framework for software product management
12	Y	Y	Y	Business process modelling: Review and framework
21	Y	Y	Y	Integration of business modelling methods for enterprise information system analysis and user requirements gathering

Appendix B. PDD activity and concept table for Figure 2-8.

Table 0-3. Activity table for Figure 2-8

Activity	Sub-activity	Description
Literature review	Perform literature review on BM	First the researcher need to review the business model (BM) papers to understand the background of business model and construct the THEORETICAL BACKGROUND of this paper.
	Perform literature review on SDN	In this step, the researcher will review the existing papers of software defined networking to understand the main case of this study.
	Perform literature review on QA	The reason to review the quality attribute (QA) related paper is because we realized that it is hard to directly combine the business model concept with the SDN concepts. QA are proved to be a good bridge for connection.
Model the existing SDN provider	Choose the existing SDN provider	In this step, the researcher will select the existing SDN provider in the market.
	Model the SDN provider with BMC	After choosing the SDN providers, the researcher will model their SDN solution/product by using business model canvas.
	Model the SDN quality model	In this step, the researcher create a quality model based on the ISO 25010 and prior studies from Haleplidis, et al., (2014) and Metzler, Metzler and Associates (2013). Those SDN features will be stored in SDN FEATURE LIBRARY for the purpose of SDN function mapping.
	Validate the model	The BMC will be validated in this step by interviewing some experts from the chosen organizations or experts who is certified and are experiences in a certain organization's products. The results can be used to revise the matrix to get the final IMPROVED MATRIX.
SDN model proposition	Collect business requirements	Meetings with the case company are set up, and business requirements are collected.
	Select the BMC component	In this step, the researcher works with the case company to select the best fit BMC components based on the requirements of the organization.
Model evaluation	Interview with vendors	This interview is conducted with the case company after THE NEW BMC FOR SDN STRATEGY is created.

Table 0-4. Concept table of Figure 2-8

Concept	Description
THEORETICAL BACKGROUND ON BM	The literature review results about business model and especially business model canvas.
THEORETICAL BACKGROUND ON SDN	The literature review results about software defined networking (SDN), include SDN market, SDN history, technical architecture, etc.
THEORETICAL BACKGROUND ON QA	The literature review results about quality attribute (QA), we also call it SDN feature groups, because each QA are a categorized feature group for a group of SDN features.
THEORETICAL BACKGROUND	The overall THEORETICAL BACKGROUND is a pool of the THEORETICAL BACKGROUND ON BM, THEORETICAL BACKGROUND ON SDN and THEORETICAL BACKGROUND ON QA.
SDN PROVIDER LIST	This is used to list our chosen SDN providers. It is generated from an SDN market report from ESG Market Landscape Report on SDN (2013)
BMC OF EACH SDN PROVIDER	Business model canvas for each organization.
BMC MATRIX	It is a table that list all the important business model canvas features and display whether each organization has achieved that feature or not.
SDN QUALITY MODEL	SDN quality model describes the key SDN functions and categorizes them into fourteen quality attributes, which are divided into three parts as the SDN architecture.
SDN FEATURE COMPARISON MATRIX	It is a table that list the important SDN feature group/QA and correspond SDN features.
EXPERTS INTERVIEW RESULTS	This the BMC results generated after the validation with experts' review. It will influences the results of BMC MATRIX and SDN FEATURE COMPARISON MATRIX.
SDN BMC DICTIONARY	Based on the VALIDATED BMC COMPATISON RESULTS, this library is created, it contains all the BMC components in our BMCs.
SDN FEATURE DICTIONARY	The SDN FEATURE DICTIONARY is created from the SDN FEATURE COMPARISON MATRIX and the THEORETICAL BACKGROUND.
BUSINESS REQUIREMENTS	The BUSINESS REQUIREMENTS are collected from the interviews with the case company.
SELECTED BMC COMPONENTS	The SELECTED BMC COMPONENTS are based on the interviews with the case company of their business requirements.
THE NEW BMC FOR SDN STRATEGY	It is a customized BMC which is generalized from the business requirements and BMC components. This BMC will be evaluated in the last activity.
INTERVIEW RESULTS FROM VENDORS	The interview results from the interviewees on the SDN vendors' perspective.
EVALUATED BMC FOR SDN STRATEGY	This is the evaluated BMC, and it is the final deliverable of the research.

Appendix C. Company list from ESG report

Table 0-5. Table6: Company list from ESG market report (Full table)

Providers	Solution competency	Main product
Arista	Cloud Networking Network Virtualization Network Programmability	EOS+ Switches
BigSwitch	Hyperscale Networking Switch Software Solution Fabric Analytics	Big Tap™ Monitoring Fabric Big Cloud Fabric
Brocade	Management Operations Server Virtualization IP Storage Networking	Switches Routers Brocade SDN controller (Vyatta controller)
ConteXtream (Acquired by HP)	NA	NA
Cisco	Business Continuity Desktop Virtualization Management Operations Network Virtualization Server Virtualization Software-Defined Storage	Evolved Services Platform (ESP) Application Centric infrastructure (ACI) Cisco Application Policy Infrastructure Controller (APIC) ONE Software Switches and routers
Dell	Hybrid Cloud Mobility Management Network Virtualization Server Virtualization Software-Defined Storage	Dell OS9 Active Fabric Controller (AFC) - for OpenStack environment. Switches (N, S, Z series)
Enterasys (Acquired by Extreme Networks)	NA	NA
Extreme Networks	Network Automation Network orchestration Network virtualization	OneController (OpenDaylight - based) ExtremeXOS Switch Router
HP	Hybrid Network Architecture Network Virtualization SDN Ecosystem	HP VAN SDN Controller SDN AppStore HP SDN Application Switches
IBM	Mobility Management Server Virtualization Software-Defined Storage	Virtual Environment Architecture (SDN VE Architecture)
Juniper Networks	Network Virtualization Network Automation Cloud management Traffic management	Contrail NorthStar Controller WANDL IP/MPLSView PTX Series Router MetaFabric Architecture
Nuage Networks	Network Virtualization	Networks Virtualized Services Platform (VSP) Networks Virtualized Services Assurance Platform (VSAP) etworks Virtualized Network Service (VNS)
NEC	Mobility Management Dynamic SDN Solutions Telecom Carrier Solution Enterprise SDN Solution Data center solution	UNIVERGE PF Series SDN Products: Controller Switches
Midokura	Network Virtualization	MidoNet

Pica8	SDN Solution	PicOS White Box Switches
Plexxi	Comprehensive Network Solutions Network Integration	Plexxi Switches Plexxi Controller Plexxi Connect
Vello	Cloud Storage Network as a Service	VelloOS Vello Application
VMware	Network Virtualization	NSX vSphere vCloud vSwitch

Appendix D. Business model canvas dictionary

Table 0-6. Business model canvas dictionary

HP	VMware	Cisco	OpenDaylight
SDN product user, SDN app developer	Mass market	Enterprise, Data center, Campus	Mass market, Cloud/OpenStack, Networking Use Case
Self-service, Dev community, Co-creation	Customer blogs, Personal assistance, self-service	Smart net total care service, Technical sales, self-service	Community & forum, Self-service [tutorial], Co-creation
Product website, Local reseller, SDN application	Product website, Local partner	Product website, Cisco direct ordering tool, Local reseller.	Product website, Project members.
SDN solution, Infrastructure sales, Customer support, AllianceOne Program	Product licensing, VMware education, Network visualization solution, Partner program	SDN software, SDN service&solution, SDN infrastructure, Training&certificate, Partner program	NA
Network customization & migration, SDN value proposition, Easy SDN App distribution.	Network virtualization value propositions	SDN value proposition	Full SDN controller, Module driven, Open source software
Platform management, Service provisioning, Platform promotion, Product development, Open project	Software development, Service provisioning, Product promotion, Open source project support	Software development, Service provisioning, Product marketing, Open source project support.	OpenDaylight Summit, Developer forum, TWS meeting, TSC meeting
Appstore platform, SDN products, SDN&network experts, SDN Vision.	Intellectual properties, Product expert	Intellectual properties, SDN & Networking Experts, Loyalty customer	Project members, Community member/Contributor
Infrastructure manufacturer, HP SDN ecosystem	SDN partner, OEM partner,	SDN partner, Infrastructure manufacturer,	Platinum member, Other project members.

alliances, Open project partner	Open source project partner.	Open source project partner,	
Maintaining and developing platform, Maintaining and developing SDN products, Open project investment, Marketing	Maintaining and developing SDN products, Open software support, Marketing	Marketing, Open source software support, Maintaining and developing SDN software, SDN infrastructure manufacturing.	Maintaining staffs, OpenDaylight summit, OpenDaylight marketing

Appendix E. SDN feature dictionary

Table 0-7. SDN feature library

Controller and management plane	Southbound interface
	network isolation(multi-tenants)
	Path discovering
	Traffic splitting
	Layer 2 & layer 3 support
	redirect traffic
	Sophisticated packets filter
	Offer a northbound API (to support other applications and orchestration system such as OpenStack
	Network Topology monitoring
	Other technology and design support (VRRP, MC-LAC)
	hardware and software redundancy features
	Clustering enabled (active/hot standby mode)
	end-to-end flow visibility
	Network virtualization
	standard protocol support
	Old (VLAN and VRF)
	New (end-to-end, abstract and pool the network resources as a server virtualization does)
	decoupled tenant-specific virtual networks
	mitigate impact of nework broadcast overhead
	minimize the proliferation of flow table entries
	span multiple sites (enables the movement of VMs and virtual storage between sites
	flow setup time & number of flows per second the controller can setup
	enterprise authentication class support
	sophiscated packet filter
	isolation tenant network
	attack awareness

	Financial (refer to the evaluation of their stock)
	Technology
	Sustainable development of the company (refer to the)
Application plane	northboud API, e.g., RESTful API
	Appstore or equivalent application platform ecosystem
	Application identification and priority enforcement
	Rule conflict detection and correction
	Malicious activity detection and mitigation
Network Device	SDN enabled physical device. E.g., OpenFlow enabled

Appendix F. Interview and evaluation process and questions

Validation with four selected organizations

Involved organizations: Cisco, HP, VMware, OpenDaylight
Interview method: Microsoft Lync conference call, regular phone call and emails.
Duration per session: 1 hour
Number of sessions: avg. 1~2 sessions per organization.
Number of people involved: 4

The interviews are conducted under a semi structure basis, which aims to validate the data we have collected and created, i.e., the business model canvas, SDN architecture and comparison matrix table. In addition, based on the answers each interviewee give, correspondent questions will be asked to further explore the BMC and SDN features. The structure of the validation focus on three parts as followings:

BMC
In this part, it shows the BMC of the interviewee's organization to validate each block by asking some simply questions. Some example questions could be:

- Could you help me validate the Business model canvas (BMC) I have created for your company?
- Do you think the BMC rightly reflect your company's business strategy for SDN?
- Do I miss any important element in the BMC?
- Do you have any other remarks on the BMC?
- What else can your company provide to its key customers?

The SDN quality model
The validation for the SDN quality model aims to verify mapping created in Figure 6-1. Thus, several sample questions are provided to ask the interviewees:

- Can I ask you some questions about the quality model I made to compare the SDN product?

- According to the literatures, we have utilized those QAs to map the important SDN functions and features into the BMC blocks, do you have any other recommendations? e.g., what kind the features do we need to add into the list?
- Is this mapping method appropriate for SDN?
- To what degree have your organization have adopted this feature? What is the capability?

Appendix G. Co creation with the case company

Involved person: Both management and operational level
Duration: avg. 1.5 hours per session
Number of sessions:

The co creation process is conducted by using the Microsoft Lync conference call. It is mainly dived into 4 parts.

1. Brief introduction of the business model canvas to ensure our case company clearly understand what is BMC and the purpose of the call. (an abstract version of Section 3.2.1 will be sent to case company a week before the call).
2. According to the sequence listed in Section 3.2.1 to walk our case company through each BMC block and ask questions to understand what are their current status and plans. It is a semi structured interview, so questions can vary based on the answers of the interviewees. Some example questions are listed below:

- What is the main customer segment of the SDN product of your company?
- Why do you choose to serve these customer segments?
- Do you understand the needs and demands of your customers?
- What kind of values can you offer to your customers?
- How do you transfer your value to your customer?
- How to maintain the relationship with your customer, and develop new relationship with potential customers?
- How much can you gain from your customers?
- What is your economic infrastructure?
- Do you know the market conditions? How do other competitors make profit in this market?
- Capital market situation understanding
- What is your value chain actors and suppliers?
- Key stakeholders (incumbents, insurgent, etc)

3. After filled in nine BMC blocks, the researcher will start to pick up BMC components from the BMC component library (Figure 7-2) to question the case company why don't they have certain components in their BMC, and discuss whether it is appropriate to subsume those components into their BMC. Some example questions could be:

- How much do switching costs prevent your customers from blending?
- How scalable is your business model?
- Does your business model produce recurring revenues? (discuss the revenue streams)
- Do you earn before you spend?
- How much do you get others to do the work? (Co creation activities)
- Does your business model provide built-in protection from competition?

- Is your business model based on a game changing cost structure? (discuss the cost structure)

4. Present the final version of the BMC to the case company, fix mistakes if necessary.

The process above will be applied to several employees in the case company, people involved are from both management and product operational/designing/development level.

Appendix H. Evaluation with SDN provider (the case company)

Involved person: Both management and operational level

To eschew ending up with biased conclusions, the evaluation activities were conducted with different people from the case company. Following the evaluation method created by Osterwalder & Pigneur (2010) in their book "Business model generation", it depicts a big picture assessment method. Second, it provides a checklist for assessing BMC's strengths, weakness, opportunities, and threats (SWOT) for each BMC block. A checklist sample could be found below:

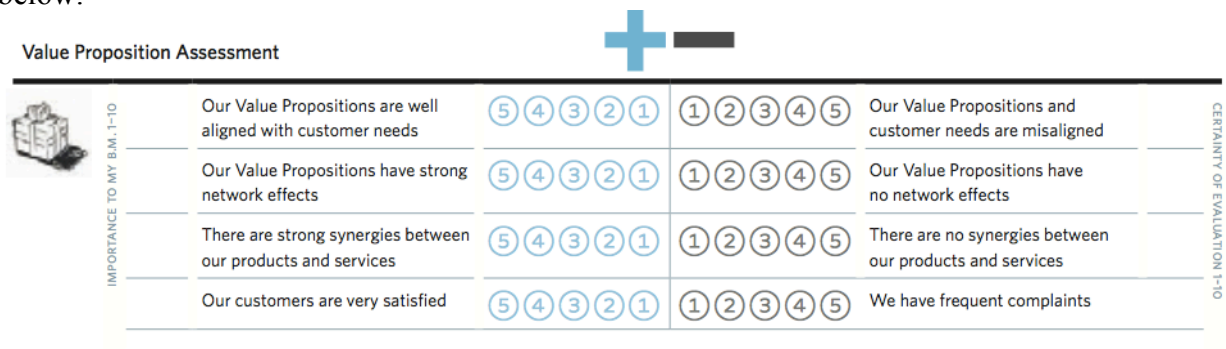

Figure 0-1. SWOT checklist sample for Value proposition assessment

Based on the results of SWOT analysis, three tables were created to show the characteristics of the case company.

Table 0-8. Strength/Weakness SWOT evaluation data entry

Strength/Weakness			
No.	Subject	Score	Result
	Offer		
1	Our Value Propositions are well aligned with customer needs	2	Strength
2	Our Value Propositions have strong network effects	2	Strength
3	There are strong synergies between our products and services	3	Strength
4	Our customers are very satisfied	1	Strength
		8	
	Finance		
5	We benefit from strong margins	2	Strength
6	Our revenues are predictable	3	Strength
7	We have recurring Revenue Streams and frequent repeat purchases	4	Strength
8	Our Revenue Streams are diversified	4	Strength
9	Our Revenue Streams are sustainable	4	Strength
10	We collect revenues before we incur expenses	-4	Weakness
11	We charge for what customers are really willing to pay for	3	Strength
12	Our pricing mechanisms capture full willingness to pay	2	Strength
13	Our costs are predictable	1	Strength
14	Our Cost Structure is correctly matched to our business model	0	Normal
15	Our operations are cost-efficient	0	Normal
16	We benefit from economies of scale	2	Strength
		21	
	Infrastructure		
17	Our Key Resources are difficult for competitors to replicate	2	Strength
18	Resource needs are predictable	3	Strength
19	We deploy Key Resources in the right amount at the right time	0	Normal
20	We efficiently execute Key Activities	2	Strength
21	Our Key Activities are difficult to copy	2	Strength
22	Execution quality is high	4	Strength
23	Balance of in-house versus outsourced execution is ideal	-3	Weakness
24	We are focused and work with partners when necessary	2	Strength
25	We enjoy good working relationships with Key Partners	-1	Weakness
		11	
	Customer		
26	Customer churn rates are low	4	Strength
27	Customer base is well segmented	2	Strength
28	We are continuously acquiring new customers	2	Strength
29	Our Channels are very efficient	2	Strength
30	Our Channels are very effective	2	Strength
31	Channel reach is strong among customers	4	Strength
32	Customers can easily see our Channels	4	Strength
33	Channels are strongly integrated	4	Strength
34	Channels provide economies of scope	2	Strength
35	Channels are well matched to Customer Segments	2	Strength
36	Strong Customer Relationships	4	Strength
37	Relationship quality correctly matches Customer Segments	2	Strength
38	Relationships bind customers through high switching costs	4	Strength
39	Our brand is strong	4	Strength
		42	

Table 0-9. Opportunity SWOT evaluation data entry

Opportunities			
No.	Subject	Score	Result
	Offer		
1	Could we generate recurring revenues by converting products into services?	5	High
2	Could we better integrate our products or services?	4	High
3	Which additional customer needs could we satisfy?	4	High
4	What complements to or extensions of our Value Proposition are possible?	5	High
5	What other jobs could we do on behalf of customers?	4	High
		22	
	Finance		
6	Can we replace one-time transaction revenues with recurring revenues?	4	High
7	What other elements would customers be willing to pay for?	2	Low
8	Do we have cross-selling opportunities either internally or with partners?	5	High
9	What other Revenue Streams could we add or create?	3	Normal
10	Can we increase prices?	4	High
11	Where can we reduce costs?	4	High
		22	
	Infrastructure		
12	Could we use less costly resources to achieve the same result?	5	High
13	Which Key Resources could be better sourced from partners?	5	High
14	Which Key Resources are under-exploited?	5	High
15	Do we have unused intellectual property of value to others?	5	High
16	Could we standardize some Key Activities?	5	High
17	How could we improve efficiency in general?	4	High
18	Would IT support boost efficiency?	5	High
19	Are there outsourcing opportunities?	5	High
20	Could greater collaboration with partners help us focus on our core business?	5	High
21	Are there cross-selling opportunities with partners?	4	High
22	Could partner Channels help us better reach customers?	4	High
23	Could partners complement our Value Proposition?	4	High
		56	
	Customer		
24	How can we benefit from a growing market?	5	High
25	Could we serve new Customer Segments?	5	High
26	Could we better serve our custom- ers through finer segmentation?	4	High
27	How could we improve channel efficiency or effectiveness?	5	High
28	Could we integrate our Channels better?	5	High
29	Could we find new complementary partner Channels?	4	High
30	Could we increase margins by directly serving customers?	2	Low
31	Could we better align Channels with Customer Segments?	4	High
32	Is there potential to improve customer follow-up?	5	High
33	How could we tighten our relationships with customers?	4	High
34	Could we improve personalization?	5	High
35	How could we increase switching cost?	4	High
36	Have we identified and “fired” unprofitable customers? If not, why not?	3	Normal
37	Do we need to automate some relationships?	3	Normal
		58	

Table 0-10. Threats SWOT evaluation data entry

Threats			
No.	Subject	Score	Result
	Offer		
1	Are substitute products and services available?	4	High
2	Are competitors threatening to offer better price or value?	5	High
		9	
	Finance		
3	Are our margins threatened by competitors? By technology?	5	High
4	Do we depend excessively on one or more Revenue Streams?	5	High
5	Which Revenue Streams are likely to disappear in the future?	5	High
6	Which costs threaten to become unpredictable?	4	High
7	Which costs threaten to grow more quickly than the revenues they support?	5	High
		24	
	Infrastructure		
8	Could we face a disruption in the supply of certain resources?	5	High
9	Is the quality of our resources threatened in any way?	4	High
10	What Key Activities might be disrupted?	1	Low
11	Is the quality of our activities threatened in any way?	1	Low
12	Are we in danger of losing any partners?	3	Normal
13	Might our partners collaborate with competitors?	5	High
14	Are we too dependent on certain partners?	3	Normal
		22	
	Customer		
15	Could our market be saturated soon?	2	Low
16	Are competitors threatening our market share?	5	High
17	How likely are customers to defect?	2	Low
18	How quickly will competition in our market intensify?	5	High
19	Do competitors threaten our Channels?	5	High
20	Are our Channels in danger of becoming irrelevant to customers?	5	High
21	Are any of our Customer Relation- ships in danger of deteriorating?	4	High
		28	