Title: Business models for network slicing in 5G

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Problem description:

The coming deployed 5G networks will have the capabilities for providing lower latency, higher capacity/throughput, higher reliability and higher number of connected devices that enable a variety of services with very different requirements and needs. The standardization and implementation of 5G incorporates virtualization techniques such as e.g. Network Function Virtualization (NFV) and Software Defined Networking (SDN) to utilize the HW available as efficient as possible to meet the service and operational requirements. An aspect of use of the virtualization techniques in 5G are network slices that network operators may choose to deploy in their networks. A network slice provides dedicated requirements and operates independently from other network slices. For instance, different network slices could be used for critical infrastructure like emergency communication services, power distribution, and water distribution. The objectives of the thesis is to explore possible business models for offering network slices in 5G networks.

The project consists of the following tasks:

- Study background literature
- Identify needs/requirements of the customers/services
- Identify benefits for the network operator
- Propose business model for offering network slices

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Abstract

The goal of this thesis is to explore a potential business model for the coming network slices in 5G. 5G network will improve services from previous generations as well as introduce new use cases. With virtualization technology, it will be possible to run logical networks called network slices over a single physical infrastructure. The network will be more customized after requirements, and will not fit all users. There are three generic use cases with heterogeneous requirements called enhanced mobile broadband (eMBB), ultra-reliable low-latency communication (URLLC) and massive machine-type communication (mMTC), that can be adapted into every possible use case.

The introduction of 5G will also lead to changes in the architecture, such as the network moving from cloud computing to edge computers, the separation of access and core network and the separation between the control plane and the user plane. This leads to a new 5G network architecture that is reorganized from earlier. The 5G network will also primarily serve business customers such as verticals, since they have better customer needs. It will be possible to move mission critical networks into the commercial network. By using edge computers the network can provide services with less latency and become more autonomous. This will lead to operations in industries that are not dependent on the core network, as they can still function if connection with the core network is lost.

Business model canvas is used to create a business model for 5G network slicing from an MNO's perspective. This model and its nine dimensions were used to form questions to an interview with different actors in the marked, such as operators, infrastructure provider, vertical and regulator. A business model canvas is then created based on the interviews to show a potential model for network slicing.

There is a lot of uncertainty in the marked, since network slice is still in a very early stage. It is also important to distinguish technical feasibility with commercial profit. In every use case, there will be a commercial negotiation to set a price for a slice. The price will be dependent on the capabilities, coverage and also on the customer. In the beginning, operators will most likely provide few types of slices, and they

can typically be generic slices. Later on, when the process of creating slices is automatized, additional type of slices will be offered.

Sammendrag

Målet med denne masteroppgaven er å utforske potensielle forretningsmodeller for kommende skivedeling i 5G. 5G-nettverket vil forbedre tjenester fra de foregående nettverksgenerasjoner og introdusere nye bruksområder. Ved bruk av virtualiseringsteknologi, vil det være mulig å kjøre logiske nett, såkalt skivedeling, over en fysisk nettinfrastruktur. Nettverket vil også være mer skreddersydd etter kravene, og vil ikke lenger passe alle brukerne. Det er tre generiske bruksområder med heterogene krav som heter forbedret mobilt bredbånd (eMBB), ultrapålitelig-lav-forsinkelse-kommunikasjon (URLLC) og massiv maskintype-kommunikasjon (mMTC), som kan tilpasses alle mulige bruksområder.

Introduksjonen av 5G vil også føre til endringer i nettverksarkitekturen, hvor nettverket går fra å være en skybasert databehandling til en endebasert databehandling, separasjon i aksessnettet og kjernenettet, separasjon av kontroll planet og brukerplanet. Det fører til en ny 5G-arkitektur som er omorganisert fra tidligere. 5G-nettet vil først og fremst ha bedriftskunder som vertikaler, fordi de har bedre kundebehov. Virksomhetskritiske tjenester kan også bli lagt inn i det kommersielle nettet. Ved bruk av endebasert databehandling vil man få tjenester med lavere forsinkelse og kan bli autonome. Det kan føre til at operasjoner i industrien ikke vil være avhengig av kjernenettverket, og kan fortsatt fungere selv om koblingen til kjernenettet er borte.

Forretningsmodellen Canvas er brukt for å lage en forretningsmodell for skivedeling i 5G med perspektivet fra en mobiloperatør. Denne modellen inneholder ni dimensjoner som blir brukt til å formulere spørsmål til intervjuer med forskjellige aktører i markedet som mobiloperatør, infrastrukturtilbyder, vertikaler og regulator. En Canvas-forretningsmodell vil bli laget basert på intervjuene, for å vise en potensiell forretningsmodell for skivedeling.

Det er fremdeles mye usikkerhet i markedet, fordi skivedeling er fremdeles i en tidlig fase. Det er også viktig å skille mellom det som er teknisk mulig og kommersielt lønnsomt. I hvert bruksområde vil det være en kommersiell forhandling når prisen for en nettverksskive bestemmes. Prisen er avhengig av skivets kapabilitet, dekning og kunden selv. I begynnelsen vil operatører mest sannsynlig tilby få typer nettverksskiver,

og de kan være på de generiske bruksområdene. Når prosessen ved å danne en nettverksskive blir automatisert, vil det bli tilbudt flere typer.

Preface

This thesis is submitted to the Department of Information Security and Communication Technology (IIK) at the Norwegian University of Science and Technology (NTNU), to complete my Master's degree in Communication Technology. The work has been done during spring 2020.

I would like to thank my supervisor Eirik Larsen Følstad for suggesting a topic that covers my interest, for all the good advice throughout the work with my master thesis, and for always helping me out. Thanks to all the participants that could have a meeting with me, and for good discussions and perspective. And to my family and friends who supported my work and always believed in me, thank you so much.

Tone Sze, July 2020.

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List of Acronyms

3G Third-generation Mobile Network.

3GPP Third-Generation Partnership Project.

4G Fourth-generation Mobile Network.

5G Fifth-generation Mobile Network.

5G VINNI 5G Vertical Innovation Infrastructure.

5GC 5G Core.

AF Application Function.

AMF Access And Mobility Function.

AUSF Authentication Server Function.

BMC Business Model Canvas.

CUPS Control Plane And User Plane Separation.

EEA European Economic Area.

eMBB Enhanced Mobile Broadband.

HSS Home Subscriber Server.

IoE Internet Of Everything.

IoT Internet Of Things.

ITU International Telecommunication Union.

M2M Machine-to-machine.

MEC Mobile Edge Computing.

MME Mobility Management Entity.

mMTC Massive Machine-type Communication.

MNO Mobile Network Operator.

MVNE Mobile Virtual Network Enabler.

MVNO Mobile Virtual Network Operator.

NEF Network Exposure Function.

NF Network Function.

Nkom Norwegian Communications Authority.

NR New Radio.

NRF NF Repository Function.

NSA Non-standalone.

NSD Norwegian Centre For Research Data.

NSSF Network Slice Selection Function.

PCF Policy Control Function.

PCRF Policy And Charging Rules Function.

PGW Packet Data Gateway.

QoS Quality Of Service.

RAN Radio Access Network.

SA Standalone.

SGW Serving Gateway.

SLA Service Level Agreement.

SlaaS Slice As A Service.

SMF Session Management Function.

SP Service Provider.

UDM Unified Data Management.

UE User Equipment.

UPF User Plane Functions.

URLLC Ultra-reliable Low-latency Communication.

Chapter 1
Introduction

The increasing amount of mobile devices and wireless traffic are drivers to the deployment of the fifth-generation mobile network (5G). It builds on the success of fourth-generation mobile network (4G) and is a significant improvement. The network will connect tremendous amount of devices and enable services that handles huge amount of data much faster, with minimum delay. This leads to technological possibilities such as self-driven cars, machine-to-machine (M2M) communication and remote surgeries.

1.1 Motivation

The telecommunication marked is preparing for the upcoming 5G network, which has the capabilities to bring newer and better services. It will support a variety of devices, and dedicate logical networks to specific groups with the same needs. Mission critical services can also be prioritized by using slices dedicated to emergency communications, power distribution or water distribution. It will also change and improve different industries, such as health, manufacturing and entertainment. 5G can also change the way we use the network in our daily lives, where everything is connected to the internet. Establishing a new generation of network takes time, and it is still in an early stage. There are also many actors involved with 5G, with different roles in the marked to enable it.

The topic is very relevant today, which looks at the possibilities 5G will bring. It will be interesting to study the technologies that is going to make it possible, and see how different actors in the marked will act and response to the changes.

1.2 Objectives and research questions

The objectives of this master's thesis is to explore possible business models for offering network slices in 5G. To understand the services that network slices will

give, and the services required. This will include a study of background literature, interviews with different actors in the marked to identify needs/requirements of the customers/services, identify the benefits for the network operator and by the use of the business model canvas, propose a possible business model.

Based on the objectives, these research questions are derived:

- What will 5G network slice give?
- What are the customer needs or what are the requirements of the services?
- Why will a network operator provide network slices?
- How can a potential business model of network slicing be?

1.3 Constraints and limitations

1.3.1 Core network

5G and network slices are a comprehensive topic, and this master's thesis will therefore mainly focus on the core network of the 5G standalone (SA) explained in section 2.1.1. The core network is also a central element, and network slicing will not be feasible without 5G core.

1.3.2 Business model

The business model proposed will manly focus on the Norwegian telecommunication marked, because the interview objects are actors from the Norwegian marked. The business model is also created for a mobile operator's perspective, since the mobile operators owns main part of the elements that are necessary to deliver service to end users. A mobile operator can therefore operate independently, while other actors are dependent on mobile operators.

1.3.3 Network neutrality

Network neutrality ensures that all internet traffic should be treated equal, regardless of sender, receiver, equipment, application, service or content[Lov03]. This will ensure that the network will be open and non-discriminating. The purpose of it is to protect the users, and keep the network neutral and not controlled by the network operator[NKO20b]. This is a European law that is also adapted in Norway [NKO20a].

Network slicing can be prevented by this law and some of the actors in the marked have expressed concerns. Based on a interview with regulator A, that is working closely with other European regulators, the law should not stop network slicing in 5G. Network neutrality should not be perceived that strictly, and will open the

opportunities for network slicing. Regulator A also expressed that not every actors agrees with the network neutrality laws, since it could destroy the opportunities to make new business models. Every possible reason is therefore used to speak against the network neutrality law, and network slices is one of them. After having conversations with different actors, it seems that the law will not fully stop network slicing. This project is therefore based on that network slices is possible.

1.4 Thesis outline

The chapters of the master's thesis is structured as follow:

- **Chapter 2 Background:** Some basic ideas is presented in this chapters, such as 5G and network slices. The customer and actors in the marked will also be presented.

- **Chapter 3 Methodology:** This chapter will look into the methodology, and it is the business model canvas and interviews with different actors.

- **Chapter 4 5G Network Architecture:** The architecture of 5G will be presented, including some changes from the previous generations such as the network moving from cloud to edge, separation of access and core network, separation between control plane and user plain.

- **Chapter 5 Business model canvas:** Based on the interviews, a business model canvas and its nine dimensions is filled out.

- **Chapter 6 Discussion:** This chapter will discuss the different factors of the business model, especially around creation of slices.

- **Chapter 7 Conclusion:** A summary of what 5G network slices will give to the customer and why a operator is providing it. The fucture use of slicing.

Chapter 2
Background

2.1 5G

5G is an upgrade from the previous generations, and promises primarily higher bandwidth, lower latency and greater connectivity for devices than before. The network can be more tailored towards the users need, going beyond previous generations where the upgrades were mainly on speed and capacity for all users. It will also handle millions of devices such as sensors, machines and cars, and it is expected to change how people use the network. 5G is the key to digitalization in different fields, including the industry. Industry 4.0 is the term for the ongoing transformation into smart factories, where machines, sensors and devices can communicate and cooperate in real-time [RP18]. This will increase automation with the use of Internet of Things (IoT) devices and robotics, and will need a robust communication network.

2.1.1 Non-standalone and Standalone 5G

The mobile network consists of two main components, the radio access network (RAN) and the core network. To utilize 5G at its full potential, it should comprise of 5G new radio (NR) and 5G Core (5GC), and are called SA version. The first type of 5G network to roll-out is the non-standalone (NSA) version, where the network upgrades the radio access technology with 5G NR and combines it with enhanced 4G radio access and core network. It is possible to upgrade the radio network independently from the core network, due to separated architecture between core- and radio network. This leads to a gradual process with upgrades in the network from NSA to a SA version of 5G, and is neither NSA or SA. It will first provide higher bandwidth and establish coverage, before SA brings new services that was not possible earlier such as low latency services. [Fox]

2.2 Network slicing

The network will support diverse customers with different needs simultaneously. By the use of virtualization technology, a single physical network infrastructure is separated into multiple logical networks called network slices as shown in figure 2.1. Each slice will be customized and configured with only the necessary functions to fulfill the user requirements and can serve a group of users with the same needs. These network slices will be end-to-end divided, through the terminal, access network, core network and transport network. They can act like independent networks with shared or dedicated resources such as the processing power, storage and bandwidth [Ass17]. In this way, it will simplify the property management of a slice. The hardware available will also be utilized in a efficient way.

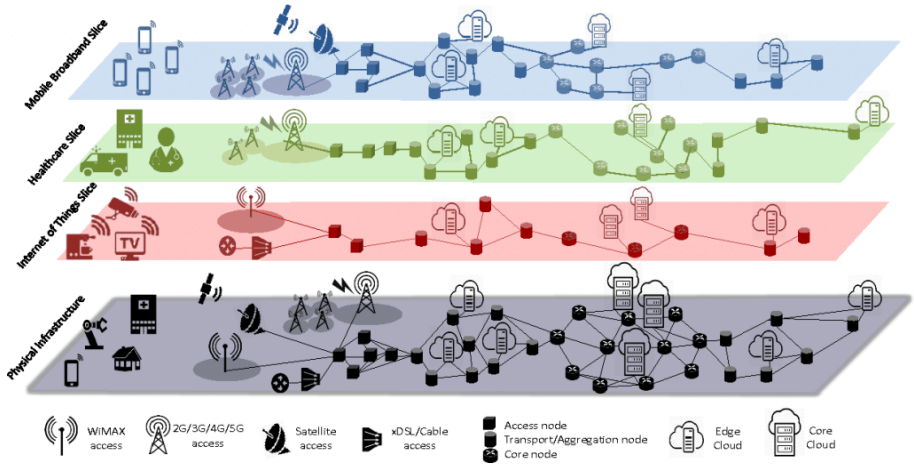

Figure 2.1: Network slicing in 5G (J. Ordonez-Lucena et al., 2017)

The standardization organization Third-Generation Partnership Project (3GPP) develops protocols for mobile telecommunications, and covers the 5G specifications. Release 15 and Release 16 are 3GPP standards that describes 5G network slicing. Different actors in the marked such as operators and infrastructure providers follow these standards, that allows cooperation of components from different providers.

2.2.1 Use cases

There are three generic services or main use cases with heterogeneous requirements, defined as enhanced mobile broadband (eMBB), ultra-reliable low-latency communication (URLLC) and massive machine-type communication (mMTC) [ITU18]. These generic use cases are decided from many potential new use cases 5G will bring and

are described by the requirements. It is therefore possible to part each of the generic use cases into many similar use cases. The eMBB slice is a direct evolution from 4G and promises higher data rates, higher traffic and user mobility in a wide area than the previous generation mobile network. URLLC is suitable for services that requires low latency and high reliability, such as mission critical communication. Vast amount of devices are now connected to the internet, and the mMTC slice will support numerous devices in a small area. The idea of the slices is also relatable to millions of IoT devices that wants to be connected to the internet, like sensors, machinery and etc. These data are sent sporadically and the payload is small.

2.3 Customer and network type

There exists two types of users in the mobile network: nomadic and static users. The static users are always on the same geographical location and nomadic users are the ones who are independent of location. For nomadic users, the networks slices should be nationwide. It can typically be private end users who belongs to this group. Machine-to-machine communication in a industrial facility on the other hand, has static users, eg. the machines will always be on the same area. To establish a slice for this use case, the slice only needs to support the area of the industrial facility and only needs a location based network. The user type is important during the planning of network slices, as it requires more to build a nationwide slice than a geographically limited slice.

2.4 Existing marked

There are many actors in the communication marked today with roles that are both similar and different. It is possible to get wireless services in many ways through a value chain as showed in figure 2.2.

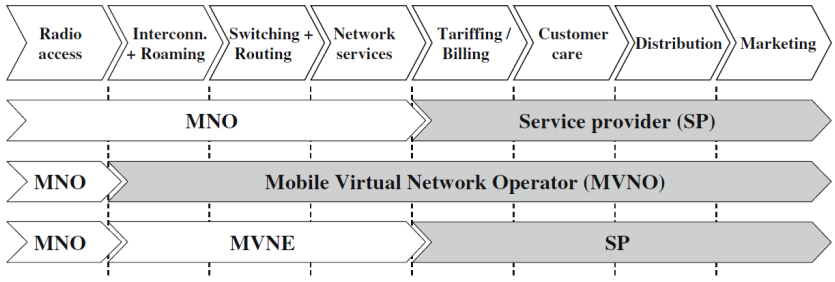

Figure 2.2: Mobile operator value chain possibilities (T. Smura et al., 2008)

A mobile network operator (MNO) is a operator that owns a radio spectrum license, a wireless network infrastructure and a core network. Since they are the only actor with its own infrastructure, they are needed in every value chain. A service provider (SP) takes care of subscriptions and billings, and can be integrated with MNO or remain independent. Mobile virtual network operator (MVNO) is acting like an MNO, but do not have their own infrastructure. In some scenarios, they have their own parts of core network and own subscription and billing system. The last one is mobile virtual network enabler (MVNE) where they resell the infrastructure to a SP. [SKH07]

The MNO buys the infrastructure from an infrastructure provider, such as radio access, transport network and core network. An MVNO is interested to lease the wireless infrastructure that MNO owns and combine it with its own hardware and services. The end users will not differ the services provided, except different suppliers and the quality they are offering.

Some operators in the marked can have significant marked power and can act independently in relation to customers, competitors and consumers. A regulator's task is to ensure that the marked has a healthy competition, and achieves that in cooperation with the Norwegian Competition Authority by regulating the dominant actors[NKO20d]. The operator will have some obligation that needs to be followed, which prevents the dominant actor to execute its significant marked power based on the size.

2.4.1 The Norwegian marked

If we investigate the Norwegian marked, there exists three MNOs that shares the marked, namely Telenor, Telia and Ice. Based on the numbers by the exit of 2019 from the Norwegian Communications Authority (Nkom), Telenor dominates the marked for mobile services with a marked share of 47,2 %, while Telia and Ice has 35,9 % and 9,8 % respectively. [NKO20e] Ice is primarily in the consumer marked, but is planning to take a bigger share in the enterprise marked. There are also many MVNOs in the marked, that are both competitors and customer of MNO, for instance Chili Mobil, MyCall, OneCall and Talkmore.

Since Telenor has the biggest marked share, the company is regulated by Nkom. The main regulation is the regulation of Marked 15, which is aimed towards the wholesale marked for access and call origination in public mobile networks, and includes access to national roaming, MVNO and service providers [NKO20c]. Access to co-location services are also a part of national roaming and Marked 15. National roaming is relevant for actors like Ice which builds their own mobile network, but is not nationwide yet.

Chapter 3
Methodology

This chapter will present the methods used in this project to answer the research questions, and includes the business model canvas and the interviews.

3.1 The Business Model Canvas

A business model is a method often used to understand and test a business idea. It describes how an organization plans to create, deliver, capture and keep its value [ØA18]. In other words, it looks at how an organization plans to create a product or service that customers are willing to pay for, and how it will generate revenue. Business models is an effective way for a business to think and explore different options, and it will give an overview of all the processes and resources that are needed for it.

The business model canvas (BMC) or the Osterwalder business model is a framework created by Alexander Osterwalder, shown in figure 3.1. It is often used in a startup process, and consists of nine building blocks. It shows the business from nine perspectives, and the interrelationship between different actors. The left hand side of the model is focusing on partners and activities with cost, while the right hand side is generating income to the business from the customer. The center of the model shows the value a business gives to the customers.

The nine building blocks are customer segment, value proposition, channels, customer relationship, revenue streams, key resources, key activities, key partners and cost structure. A description of every dimension is listed in table 3.1 [Sze19]. BMC is easy to use and gives a good overview of the business and is therefore used early in the process of establishing new businesses.

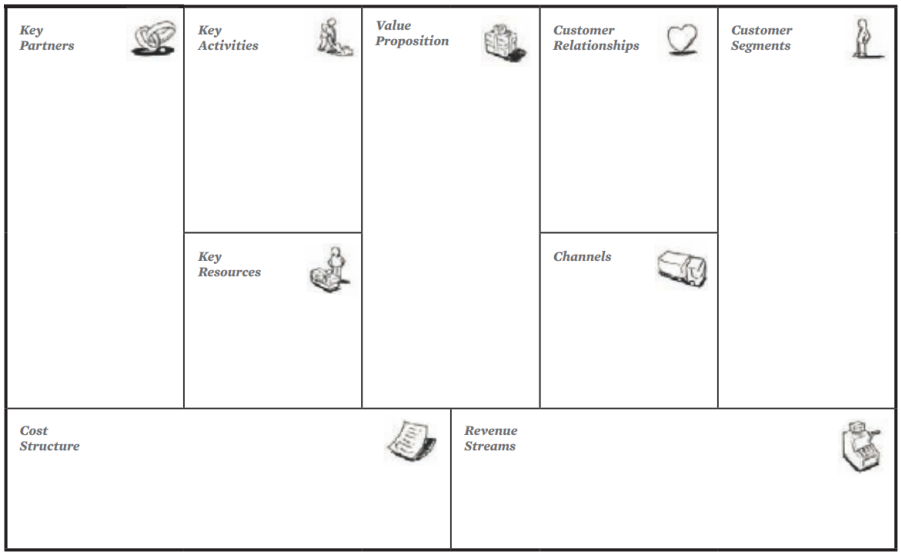

Figure 3.1: Template of BMC (A. Osterwalder & Y. Pigneur, 2010)

To understand network slices, the BMC is used. It is a great model to use to better understand different parts of a product or service. It breaks a big task into smaller parts or dimensions, and it is possible to look at each dimension separately. The model will also give a good overview of the idea in the end. The goal of using the model is to investigate what a network slice is, what it will give, who will benefit from it and how to deliver it. Since the mobile operator will most likely deliver network slices, the business model will take an operator's point of view. By using the business model canvas, a possible business model will be created.

3.2 Interviews

Interviews are a qualitative research method used to understand a research problem by marked research. The goal is to seek for answers to a problem with a predefined process, and collect information. It can lead to findings that was not expected beforehand, and findings that are beyond this study and therefore not applicable. [MWM+05] The advantage of interviews is that questions can be open-ended, and let the participant respond in their own wording. They are also a conversational communication that allows for discussions in a wanted direction.

To understand 5G from different actors in the mobile communication marked, interviews with operators, infrastructure providers, regulator and verticals were performed. All but one of the meetings were originally scheduled to be in person,

Table 3.1: Dimensions of BMC.

Dimension	**Description**
Customer segment	Who are the customers? Are there different types of customers?
Value proposition	Why are the business created at all? What are the benefits from the company that is offered to the customers? It describes the goods and services produced by the company to the customers, and the benefits the customer is getting by using the goods and services.
Channels	How is the value delivered from the company to the customers?
Customer relationship	What are the relationships between the customers and the company?
Revenue streams	How are the customer generating income to the organization? Are all customers generating the same income?
Key resources	Which key resources are needed to preform key activities and to create and offer value to the customers?
Key activities	What are the key activities needed to create and offer value to the customers?
Key partners	Which key partners are involved in the company to create and offer value to the customers?
Cost structure	What are the costs for different elements that contributes to the organization? Including the cost of the activities.

but the plan changed due to the Covid-19 pandemic. An interview with an virtual mobile operator was also scheduled, but they could unfortunately not attend after all, with the same reason. These actors were chosen since they all have different roles around network slicing, and it is interesting to see the interrelationships between them. The method used to find the candidates is the snowball sampling technique [Zac20], which started with the interview candidates recommended by the supervisor of this thesis. Some of the candidates then recommended other persons that were suited for this project. Interviews were also performed with multiple actors with the same role in the marked, to see the differences between them.

Before the interviews could be conducted, an application to the Norwegian Centre for Research Data (NSD) was submitted for managing privacy information. NSD is responsible for research data, and archives them. Information such as names, e-mails, other information that could identify a person, and audio recordings were used for this project, and were required to be reported to NSD. To submit the application to NSD, an information letter about the project and an interview guide must be

included. These are also included in Appendix A and Appendix B. The information letter was sent to all actors, to make sure they fully understand the scope of the project. The interviews were recorded to make the transcription easier, and were deleted in a secure way after this project. To anonymize and not identify different actors, the actors are denoted by their role or position in the telecommunication marked and an alphabetic letter and also to clearly show that it is retrieved from the interviews. This is to distinguish and be consistent to the information that are given by the interviewees, and an actor can be represented by more than one interviewee as specified below. This project includes these actors:

- **Operator A:** Represented by one person.
- **Operator B1 & B2:** Represented by two persons in separated interviews.
- **Operator C:** Represented by one person.
- **Infrastructure A:** Represented by one person.
- **Infrastructure B:** Represented by two persons in the same interview.
- **Regulator A:** Represented by two persons in one interview.
- **Vertical A:** Represented by one person.

The interviews were semi-structured, where the questions were formalized more open-ended. The interviewee could emphasize what they thought were important and what they wanted to elaborate. This led to new ideas and perspectives that were originally not thought of. Most of the interviews ended with good discussions, which is an advantage of semi-structured interviews. The interviews were based on the BMC, and questions were formed after the nine building blocks. Not every dimension were equally important for all the interviews, the dimensions that was focused on for each interview was therefore selected in advance. The dimension are listed below with the actors that was mainly in focus during the interview.

- **Customer segment:** Operators and vertical.
- **Value proposition:** Everyone.
- **Channels:** Operators.
- **Customer relationship:** Operator, infrastructure provider and regulator.
- **Revenue streams:** Operators and Infrastructure providers.
- **Key resources:** Infrastructure providers.
- **Key activities:** Operators, infrastructure providers.
- **Key partners:** Operators, infrastructure providers and regulator.
- **Cost structure:** Operators, infrastructure providers.

Each meeting was scheduled to be approximately one hour, but the meeting lasted between 45 minutes to one and a half hour. One of the interviewee was able to do a follow-up interview, where others kindly answered questions on e-mail. It was interesting to see the differences and similarities from different actors. The actors

represented their role in the marked rather than the company they were working for, and also tried to answer from other points of view.

Chapter 4
5G Network Architecture

This chapter will delve into the 5G architecture, and look at how the network is build up and changes to the network from previous generations. This includes how the network is moving from cloud computing to edge computing, the separation of access and core network, the separation between control plane and user plane, and how the core network is build up. Each of the network functions will be briefly explained.

4.1 From cloud computing to edge computing

Cloud computing delivers computing services over the internet, with a centralized pool of computing resources such as networks, servers, application and services [DWC10]. They can be provisioned and released on-demand which makes it convenient. The use of cloud computing can benefit the customer in many ways. Instead of investing on own computer resources, it will more cost effective to use cloud-based services. In this way, start-up and operating cost will be lower by not investing in own infrastructure. It is also possible to scale the resources after need, since the resources are shared among many tenants [WGF15]. This makes all the services more flexible. The risk is also reduced by outsourcing the resources to the cloud provider. Mobile cloud computing uses cloud computing to deliver mobile services.

Mobile cloud computing slowly moves towards MEC, due to the latency-critical and computation-critical services 5G brings [MYZ+17]. The edge computers will have the same benefits as cloud computer, but also solve the main problem which is the long propagation delay. The computation power, storage and network management is shifted to the edges and closer to the users. This promises significantly reduction in latency and harvesting the computation power and storage space at the edges as shown in figure 4.1. The distance between the user and the edge computer, determine the propagation latency. The information is computed at the edges and does not pass several networks such as access network, back-haul network and internet. It is therefore not necessary to take the communication latency into account. The use of

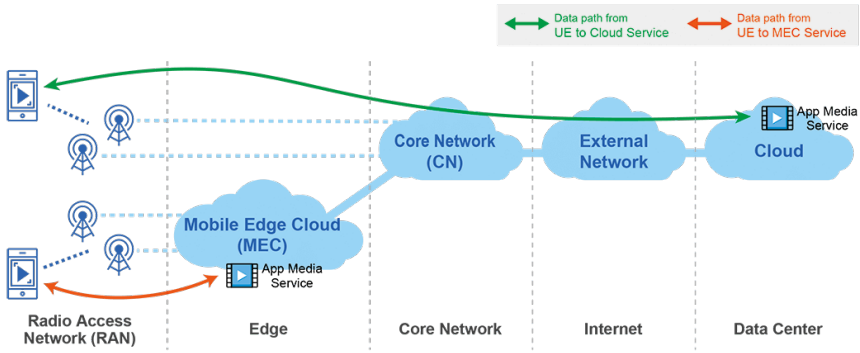

Figure 4.1: MEC and cloud computing travel path (GIGABYTE (2020). https://www.gigabyte.com/Solutions/Networking/embb, Access Date: 23 July 2020)

edge computing will lead to possibilities for new applications and services.

4.2 Separation of access and core network

The separation of access and core network started already in the third-generation mobile network (3G). There are not any standard rules or guidelines for the separation, but the standard that 3GPP sets, shows a clear functional separation between access and core network in 5G [TN20]. The dependency between the access network and the core network has also been minimized, it is therefore possible to upgrade the network from NSA to SA gradually.

4.3 Control Plane/User Plane Separation

Control plane is a set of functions that carries signaling traffic, and determines the path all of the traffic will use. User plane, also called data plane, is responsible for the forwarding traffic. Control plane and user plane separation (CUPS) refers to the separation between control plane and user plane, and makes the scaling independently. This was an option in 4G core network. The control plane can be centralized and handle the management, while the user plane can be distributed [LSC+17]. It will therefore be possible to put the user planes at the edge computers to achieve the latency requirements.

4.4 Core Network Architecture

The core network architecture of 5G is service based and provides a modular framework. The components have been reorganized from the previous generations, and the architecture is more compatible with different vendors, products and technology.

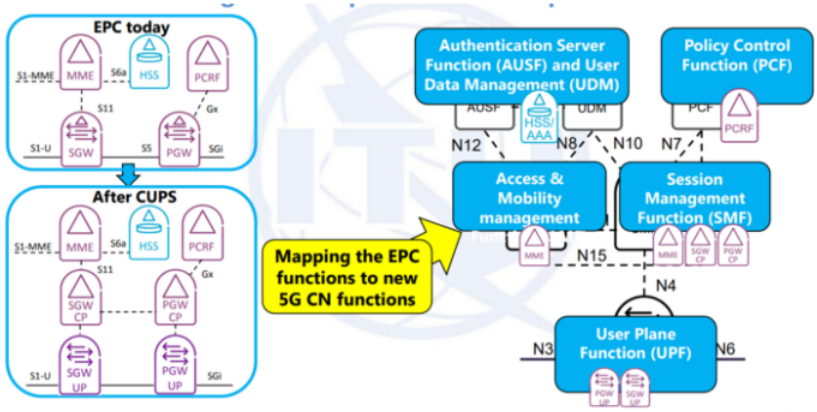

Figure 4.2: Evolution of 5G architecture (ITU, 2017)

The CUPS is also the first step towards the 5G architecture, where both Serving Gateway (SGW) and Packet Data Gateway (PGW) were splitted into control plane and user plane components as shown in figure 4.2. The data plane are linked together with a solid line, while the dotted line indicates the control plane. This leads to a reorganization in the architecture.

5G core architecture consists of functional building blocks called network function (NF), and is a mesh of interconnected services as shown in the figure 4.3. To fulfill the requirements of 5G, the architecture has been flatten. [Det18], [Eve18] and [Kö19] defines NFs as follows:

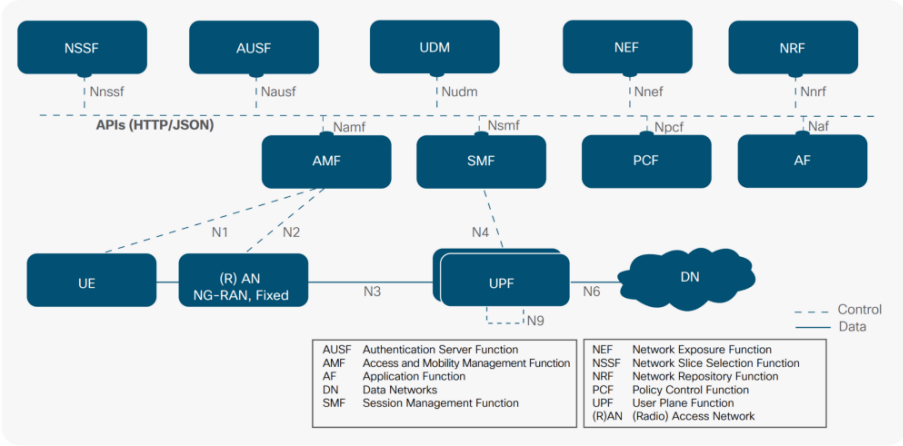

Figure 4.3: 5G System Architecture (Cisco, 2018)

Access and mobility function
The function of access and mobility function (AMF) is to receive all the connections and handle all the sessions related information between the user equipment (UE). This includes registration management, connection management, reachability management, mobility management and functions related to access and security management and authorization. This function carries out most of the functions 4G Mobility Management Entity (MME) is responsible for. An AMF instance is serving all the network slices UE is a part of, which gives AMF a good overview of the functions the UE has.

Session management function
Session management function (SMF) is one of the main functions in 5G core, and completes the session managements such as establishing sessions, modify and release it. SMF can handle IP address allocations, select and control the traffic routing and etc. In 4G SMF was handled by MME and the core part of SGW and PGW.

User plane functions
As presented in section 4.3, the user plane functions (UPF) is responsible for routing and forwarding the traffic, as well as packet inspections, quality of service (QoS) handling, and etc. This consist of the user plane part of SGW and PGW.

Policy control function
The policy control function (PCF) provides the policy rules for control plane, such as QoS, filtering and charging. This will control how the network will behave, and was previously handled by Policy and charging rules function (PCRF) in 4G. In addition it will also include network slicing, roaming and mobility management in 5G.

Authentication server function
The authentication server function (AUSF) will support authentication for both 3GPP and non-3GPP access, and also store keys for authentication. This acts like a authentication server and was a part of Home Subscriber Server (HSS) in 4G.

Unified data management
Unified data management (UDM) is a repository for information related to the UE, such as user identification, access authorization, subscription management, AMF details and SMF of the current session. This is a central database for UE. This was a part of HSS in 4G.

Application function
The function of an application function (AF) is to interact with NF in other control planes. It will support application influencing on traffic routing, accessing network exposure function (NEF) that will be explained under and interaction with the policy control.

NF repository function
NF repository function (NRF) will make it possible for network functions to discover each other, and maintain NF profiles and available NF instance.

Network exposure function
The NEF shows the capabilities of the network and events, secure information from an external application to 3GPP network. It is also responsible for the transmission of information both internal and external.

Network slice selection function
Network slice selection function (NSSF) directs the traffic to a network slice that will serve the UE.

The latter three functions are the new functions due to network slicing, and were not present in the previous generation. It will also be easier to upgrade a function separately and reuse the NF, due to the modular framework. By using virtualization technology, the core network has been shrunken in size [Eve18].

Chapter 5
Business Model Canvas

BMC is used to understand the nine dimensions of 5G network slices. The following sections will cover each of the dimension from an operator's perspective. This model is also mainly based on the interviews with different actors in the marked.

5.1 Value proposition

The product or service a business creates to the customer segment is the value proposition. It is important to create something customers want. Network slicing is a service operators want to offer, to fulfill different customer needs and meet the emerging requirements. The goal is to create a flexible network that has the ability to support the coming services. A group of users with the same requirements will join a network slice for this specific purpose. A network slice has capabilities such as data speed, quality, latency, security and services, and these can be customized after need [Ass17]. The goal is to meet the end users service level agreement (SLA).

5.1.1 Generic use cases

As aforementioned, there are three generic use cases named eMBB, URLLC and mMTC categorized by the International Telecommunication Union (ITU) [ITU18]. These use cases will improve the services and offer new services that is not possible to fulfill with the existing 4G network. All the operators and infrastructure providers have also used the main use cases as the foundation to reach the standard sat by 3GPP. To achieve network slices with different requirements, the resources will be allocated to the slices to guarantee the performance and isolate them from other slices. [PTSD18]

Enhanced Mobile Boardband (eMBB)
The eMBB slice will be the first slice available and is already possible with the NSA version, and only requires an upgrade in the radio access network. eMBB will give high-speed services that is stable in crowded areas both indoor and outdoor. The

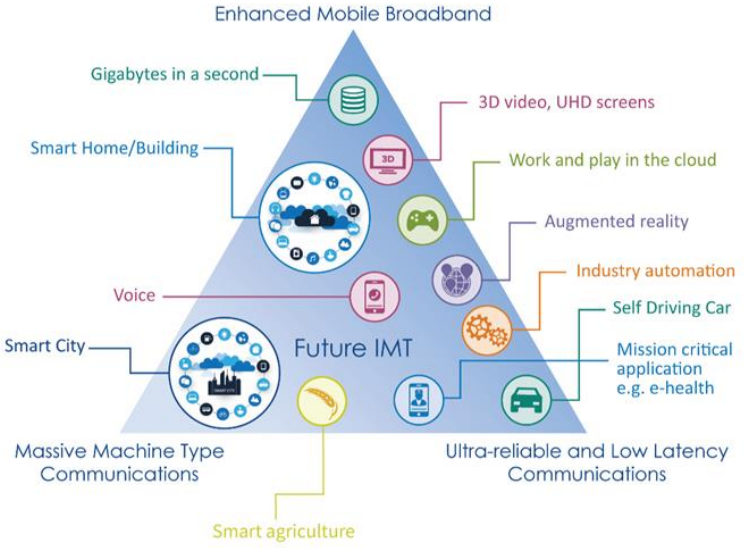

Figure 5.1: Use cases (ETSI, 2019)

payload is used to be large, and connection to the device is stable over a time interval [PTSD18]. This can also be used as an alternative to the fixed line services today, and it is faster to enable wireless network in areas than fiber network that has not been laid.

Ultra-Reliable Low-Latency Communication (URLLC)
The URLLC slice is also called the slice for mission-critical communications. This slice support services with small payloads with low-latency and high reliability [PTSD18]. Services such as self-driven cars and remote operations belongs to this slice. It will enable services that has strict requirements related to latency, and introduce services that is in real-time. To achieve the low latency, it is dependent on the distributed core network and edge computers. To achieve the lowest latency, it is possible to move the computation power to the base station. The traffic must not travel a long distance to reach the core.

Massive Machine Type communication (mMTC)
The increased amount of connected devices leads to mMTC, and will support many various devices such as IoT, Internet of Everything (IoE) and Industry 4.0. These devices are categorized as devices that can communicate without human intervention. These devices sends small payloads of data and are only sporadically active [PTSD18].

This leads to a unknown active devices at any given time. There is no problem serving machine type communication today, the problem is the number of devices served [BPW+18].

5.1.2 Possible use cases

These three generic services with the key properties will support all of the use cases. It is done by splitting all the physical infrastructure into multiple logical slices, where each slice is isolated from other slices. It can also be that a customer wants a very specific service, and an operator will create a custom slice after these specific requirements. According to most of the actors in the marked based on the interviews, slices will be created after a customer need. To establish the slice, some upgrades must be done to the existing infrastructure and adding some new components if needed.

The Norwegian public safety network
There are many verticals that builds their own network according to vertical A. One of them is the Norwegian public safety network, and is therefore one of the possible use cases. It is a nationwide public safety network that provides reliable communication, and is mainly used by the police, health services and fire and rescue services for dealing with emergencies, rescue operations and overall preparedness [DSB]. The network can only be used for predefined group communications and text messages. Until today, it is not possible to put emergency critical network in the commercial network due to the security, functionality and coverage reasons. By using network slicing, it can achieve the requirements that is needed in a emergency network. Vertical A says that the network will be more decentralized and less vulnerable for disruptions with the use of 5G. The network will also be end to end isolated from other slices, and can only communicate within a slice. Services can also be directly implemented within a slice, in both the core and the edge computers. By using 5G network slices instead of their own network improves the network to include other services that requires more capacity such as video calls.

Edge computers are not always used for latency-critical services, but also for ultra-reliable services, secure and autonomous networks. Edge computers will be used for some functionalities, and can carry some services independent from the core network. This means that the network will not be completely dependent on the core, and can work partially without the core. The mission critical services will be placed on the edges, while other services will be placed in the core network. The services will function even when critical events or disasters occurs, and simple services such as communication with other users linked to the same edge computer will be possible. Vertical A mentioned that it can be interesting for airports, hospitals, and other critical facilities to have these edge computers that will only support simple services

and can be totally independent from the core. These services can be push to talk, chat, phone calls and video for monitoring. According to Operator B1, the edge computers can be stored at caverns to satisfy safety requirements and they will also be safe from disasters and are bombproof.

Lifting cranes
Infrastructure provider B suggests that autonomy can also play an important part in ports, since they are far away from urban areas. The register function can be centralized while other functions can be at the edges, such as coordinating the lifting cranes that move containers. Vertical A says that some industry wants to use the network slices for the industry, and do not wish to have communication with the internet since it is not necessarily. It should be possible to operate with the lifting cranes without the core network. Edge computers with low latency will also be used in M2M communication to prevent machines such as lifting cranes to collide into each other as they need to be controlled with precision. Some verticals will also be an MVNO since they have their own services and edge computers, and combining it with a network slice from an MNO. This is due to privacy reasons, and that the content does not leave the company.

Vehicle to vehicle communication
In the future, it will be possible for autonomous cars to communicate with each other. Some services will get much better user experience with lower latency than minimum requirements needed to realize the services. It is possible to build autonomous vehicle without 5G, but the user experience can be better [Sut18]. Instead of a emergency break being applied immediately, it is possible to break gradually for a better user experience.

Online gaming
Some real-time online games can require low latency and high capacity. These requirements can be fulfilled in two different ways. A operator can customize a slice to all games that have the same requirements, and offer it to gamers that want to get the extra service. Different players will then be a part of the slice when they play games, and it is an extra service bought by the end user. A game company can also offer a slice to all the user of the game, and they will automatically be a part of the slice when they start the game. This will be for a specific game, where different users will share the same slice. This will guarantee a good user experience.

This can also be adapted to other companies and services. Streaming services can be another example, where a customer buys an extra service to get better quality and less delay. The streaming services can also offer a slice to the end users for better experience of their services.

Operator C suggests that the willingness for this kind of slices is still low, but

it will be possible in the future. The operator will not always be holding all of the information in the early stages, but the possibility is there. The question is how they should be developed and implemented.

Roaming slice
It will also be possible for an operator to buy access in a network slice from operators in other countries. All travelers from for example Norway can use the same slice in the country they are visiting. In this way, a Norwegian MNO will act like an MVNO in other countries. They will then offer roaming in other counties for their own customers.

5.2 Customer segment

The customer segments are the ones that benefits from network slicing, and are often grouped after the same requirements. Business customers or industrial customers are one of the many users of 5G, they are also the group that benefits the most from network slicing. Business customers consist of enterprises, verticals and individual customers[Ass17]. Verticals are a group in a special industry that have the same network requirements and can potentially share a slice. 5G is also called the first generation of industrial mobile network based on a interview with infrastructure provider B, and will open up new opportunities for different industries.

Another segment is private end users. A group of private customers can also share a slice when they are using the same service, such as online gaming, VR and AR. When the user is using the service, it will automatically use the slice dedicated to it.

The MVNO, virtual operators, are also customers of MNOs, since they are leasing the infrastructure to resell. And similarly for SP.

5.3 Channels

It is possible to get access to different network slices from MNOs and MVNOs. For an end user the network slice will be transparent and give the same services in a better way than without the network slices. According to operator B2, the slices will not be sold as slices, but as a service given by the slices. The network slices are basically a prioritization mechanism to guarantee some services.

Operator A believes that network slice can be bought in different levels, and customer can choose what they need. In this way, they can combine the services with their own hardware. Users will most likely buy Slice as a service (SlaaS), since the value of having own is low. It is expensive to have your own, as the operational

cost and maintenance are expensive. However, it is always a commercial perspective to it as the goal is to get it as cheap as possible.

5.4 Customer relationship

The goal is to fulfill the customer needs, and offer some extra to get higher income. The relationship between MNO and MVNO can be as customers, but also competitors. The infrastructure the operator is leasing out is for is a potential customer they could have gotten.

It will be possible for verticals to obtain radio frequency, and combine it with infrastructure from a infrastructure provider and not involve the MNO at all. In this way, the infrastructure provider will compete with the MNO. Operator B2 says that a infrastructure provider would rather be in a three way collaboration between with MNO, infrastructure provider and vertical, than compete against an MNO. This is because the operator is often the biggest customer of a infrastructure provider.

5.5 Revenue streams

The main generation of income are customers using network slices, but an operator will also generate income from the edge computers that are an important part of network slicing.

5.5.1 Customers

An operator gets its revenue for every customer they have, but the revenue can be different depending on the customer. The income per user is higher in the business marked than in the private marked. The willingness to pay varies among the customers, when a customer requires more complex services they will also be more willing to pay. Small companies will most likely not require complex services. The revenue will also be based on the commercial negotiation, and it is not necessarily true that two companies with the same requirements will pay the same for the services.

5.5.2 Edge computers

By using edge computers, an MNO can also generate revenue by providing access to the MEC platforms. A content provider can save the most popular content on the edge computers, with leads to shorter travel path. This is beneficial for both of the actors, and protects the network from extra traffic by pushing the content to the edges.

5.6 Key resources

The primary resource is the infrastructure, both hardware and software. An operator is dependent on the infrastructure delivered by a infrastructure provider, and that the equipment is following the 3GPP standards. The 5G network will have a totally new core, and works best when it covers a large geographical area. As infrastructure provider A said, this is because it do not have to do handovers between the 4G and 5G core if the network is not nationwide. It will not be optimal, and will lead to delays. Most of the transport network will be the same, but the operator must upgrade for better capacity.

Creating a network slice will not be automatically based on the operators, and currently it is a lot of manually work. The manual configuration are dependent on labor, and is expensive. This also brings the possibilities for manual errors, and will not be discovered right away. The goal is to automate it, but it takes time. Scaling of slices will also be done by the employees, and are also facing the same challenges.

5.7 Key activities

Creating and scaling the network slices will be the key activities related to network slicing. If the scaling is done manually, it will normally take some days according to operator A. It will also be dependent of customer size, and take less time after the start-up phase.

5.8 Key partners

Some key partners are giving services to the operators like infrastructure provider, while others are setting some requirements that needs to be followed.

5.8.1 Infrastructure provider

An operator is dependent to get infrastructure from a provider to deliver the services. Since network slicing has a modular architecture, it is possible to combine different vendor companies. When the network goes from nsa to sa, it will most likely only be a software upgrade. Both the modular architecture and software based architecture leads to a more independent operator, and less lock-in time to the same vendor. At the same time, the shifting cost will be higher if a operator chooses to change infrastructure provider. Vertical A says that competition and diversity is good for the marked, so that not all operators are using the same infrastructure provider.

5.8.2 Regulator

A regulator is not a direct key partner, but operators that are regulated must follow the rules sat by the regulator. According to regulator A, the goal of the regulator is to ensure a healthy competition, and not regulate more than needed. They will observe the marked and regulate if needed, and when the competition in marked is present, they will stop the regulation.

5.9 Cost structure

Realization of slices with different parameters will have a different cost. Slices with higher capacity, lower latency and larger geographical coverage will have a higher cost. It will also be dependent on the area, if there are many potential users it will be possible for more customer to share the same infrastructure and services. The existing infrastructure will also have an impact, as it costs more to set up a complete infrastructure than just upgrading the existing infrastructure. Number of slices determines the complexity of the network and when a network is complex, it will lead to higher costs due to operational cost and maintaining.

To achieve low latency requirements, an operator must invest in distributed networks and edge computers. It will be expensive to build a nationwide network, and an operator will therefore most likely start in large cities such as Oslo, Bergen, Trondheim and Tromsø.

Operational and maintenance costs are also costs the operators has to deal with. An MVNO do not have to deal with these cost for the infrastructure, since they are leasing it from an MNO.

Chapter 6
Discussion

6.1 Uncertainty

Network slicing is still on a very early stage, and most of the actors in the marked is primarily focusing on the NSA version of it. The upgrade is at the base stations and antennas, and the end devices must also support 5G first. Some requirement are not clear when the interview was done, Release 16 freeze was completed around mid 2020. Based on the interviews, the infrastructure provider is focusing on the technology to enable slice as the operator requests. Operators wants to deliver better services than the services today, which leads them to higher profit than with the existing technology. They will also make the slices more tailored to fulfill different requirements. The technology is available according to infrastructure provider B, but there must be good and attractive use cases to thrive.

6.2 Technical vs. commercial

It is important to distinguish technical feasibility and commercial profit. It is technically possible to place multiple customers in one slice, but due to simpler business rules an operator will rather offer one slice per customer need. According to operator A, there are to main drivers to network slicing. The first is to fulfill customer needs which will lead to higher income and the second one is to use network slicing as an operational tool to divide the network into smaller sections to make it less complex.

An operator will not build infrastructure if it does not have potential to generate income. The investment to something that will not be used, will just be wasted and leads to economic loss. It is therefore important to find good use cases before investing in them.

6.3 Sharing economy in telecommunication

Vertical A is looking at the network slices as sharing economy at the network, since different users will be sharing a common infrastructure. The resources will also be dedicated to different slices when it is needed. All the actors contribute or invest in the physical infrastructure that is shared in the marked, instead of building on a dedicated network such as the The Norwegian public safety network [For19].

6.4 Network slices

In the beginning, creating slices will be done manually and the implementation takes time according to operator A. There is also a risk for human errors when most of the work is done manually. In the long run, it will be possible to create network slices dynamically. Infrastructure provider A says it will be possible to add the parameters that define the slices, and the slice will be created after some seconds. Based on infrastructure B, it will be possible to dynamically create and remove slices. If an emergency is happening in a factory, like a fire, it will be possible to enable a slice on the fly. If there is no capacity for it, it will also be possible to remove a slice for manufacturing to enable the emergency slice.

6.4.1 Number of slices

Operators have different marked and different strategies, some are focusing on the business customers while others are focusing on private customers. The number of slices will therefore be based on their business model, and are dependent on the operator who will be offering them. In the beginning there will be few slices, but when the process is automated there will be many more slices. It is possible that the first network slices will be defined as the three generic use cases with predefined capabilities, and they will be the template for the slices customer can choose from.

Only the customer with willingness to pay, will invest in a slice at the beginning. Many slices will increase the hardware component and also the complexity of the network. As an operator, they will look at the commercial aspect, because sometimes the complexity also leads to higher income. In the long run, different customers with the same needs will not share a slice either. This is due to simpler business rules, and the possibility to upgrade capabilities within a slice. If two customers share a slice, a customer do not want to pay more for the service than the other customer. It will also be a lot easier to upgrade a slice that are not dependent on other customers, and it will also increase the willingness to pay when it is customized.

A vertical may also have very specific requirement, which makes it complicated to share slices with other customers. It can be customer need such as the isolation

from other slices, or other requirements that other customer do not need. It is also important to keep in mind that the complexity will increase with the number of slices created.

6.4.2 Pricing

The cost of a network slice will be dependent on the hardware required to realize it, but the income are mainly focused on a commercial negotiation according to operator A. The size of a company will also have different needs and ability to pay, and will affect the pricing of a network slice. The goal for operators is to optimize between complexity and income that will be generated. It is not necessarily that two customers with the same requirements will pay the same for the slices, it relies on the commercial negotiation.

6.4.3 Coverage

A network slice can be nationwide or geographically limited, and an area can therefore be covered by more than one network at a time. It is also possible for two geographically slices to be in one area, and the slices that are used will be dependent of the service.

6.4.4 Advantages by offering slice

Both Operator C and Regulator A mean that there are competitive advantage to offer network slices. If there are customer requesting these kinds of services, and have the ability to pay, it will be commercial profitable. Regulator A also adds that a mobile operator always looks at the demand before creating a service, the revenue must be high due to the development cost. Another motivation is to create services that stands out from the competitors, or services that are not created by others yet.

6.4.5 Custom Defence slice

One of the use cases that is testing out is a defence slice. 5G Vertical innovation infrastructure (5G VINNI) is a European research and innovation project that consists of 23 partners from the operator side, academy and infrastructure provider [Tel18]. 5G VINNI is working with The Norwegian Armed forces, that is one of the verticals that needs its own tailored network slice. They are early with customized network slice and have many requirements in their network. From [Nom19], a defence slice will be defined with safety, robustness and flexibility in mind. The defence slice will support end-to-end encryption and support real-time communication, coverage on-demand and autonomous MEC when the core network is now available. They will also be using all networks, both military and commercial network, and create slices on demand. A defence slice will not cover all the use cases the Norwegian armed

force has, another slice is also needed for the daily use which is separated from the operational use. Based on this slice, it shows that it will be possible to create a slice after customer needs.

6.5 Europe and network slicing

The Norwegian Electronic Communications Act and the Norwegian regulation are based on the European regulation. It is important with harmonization within Europe so that actors operating in several countries will meet the same regulation. According to regulator A, it can hinder investment and leads to poorer services in the country where the regulation is considered less advantageous, unless there exist national differences that can justify it.

Through the European Economic Area (EEA) agreement, parts of the directives that regulates the electronic communications sector is included, and converted into the Norwegian electronic communication laws and regulations. In December 2018, a new regulation was added in the EU regulations. All members are working to transform it into the national regulations, and Norway is also one of them trying to adapt the laws. There are good cooperation with supervisory authorities in other European country that are dealing with the same adaption. The laws should be fairly similar in the European countries, unless there exist national differences.

Chapter 7
Conclusion

The future network will be different from what we are used to at this moment, and is made to meet the emerging needs. 5G network will support the emerging devices that are connected to the internet, requesting all kinds of services. The network will support different and many devices at the same time, and serve them with the capacity that are needed. Network slices will also provide better communication between machines. It will therefore be possible to be a part of different slices, and the slice that are used are dependent on which service one uses.

Operators will provide these services to prepare for the emerging network, and to achieve the requirements requested from the customers. By offering it, they will also generate higher income. Operators will offer services to new user groups that are willing to pay for it.

5G network slice will primarily support users from the business customers, such as verticals in the beginning. The amount of slices will gradually increase based on the customer needs. Creating and scaling slices will go from manual procedures to be automatically implemented. A network slice will meet the requirements that are demanded, with parameters such as speed, capacity, throughput, latency, security and coverage.

Edge computers will be an important technology for both supporting the low-latency services and also autonomous services that will be needed by many different verticals. It will be possible to use the network without the dependency to the core network, and the future network will most likely be more independent from the core network than the present network. Different dedicated networks will also be placed in the commercial network. Services that was possible before network slices will also benefit from it by improved user experience.

In the long run, when the 5G network reaches nationwide coverage, it will be possible that every customer need will get a custom slice for their own requirements.

Only the infrastructure needed will be dedicated to the slice, to optimize the use of resources. Network slices are definitely something customers will need to fulfill their requirements, and will make room for the coming services and needs.

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Appendix A

Information letter

Vil du bidra i min masteroppgave om

"Forretningsmodeller for skivedeling i 5G"?

Dette er et spørsmål til deg om å delta i et intervju hvor formålet er å utforske mulige forretningsmodeller for skivedeling i 5G. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Intervjuene er en del av en masteroppgave i kommunikasjonsteknologi på NTNU, hvor formålet er å finne mulige forretningsmodeller for skivedeling i 5G. Det vil være aktuelt å snakke med forskjellige aktører med innsikt/kjennskap til 5G-nettet, og det er derfor du har blitt kontaktet. Informasjon som hentes ut av intervjuene vil bli brukt i masteroppgaven, og vil gi nyttig informasjon om hva som er viktig for deg og din bedrift fra deres perspektiv.

Hvem er ansvarlig for masteroppgaven?
Masterstudenten Tone Sze er ansvarlig for oppgaven sammen med Eirik Larsen Følstad som veileder.

Hva innebærer det for deg å delta?
Deltakelse innebærer et intervju som varer ca. en time, og vil inneholde spørsmål relatert til din og bedriftens kjennskap til og muligheter ved bruk av skivedeling i 5G. Det vil bli tatt notater og lydopptak av intervjuet dersom deltakeren samtykker dette.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Informasjonen blir behandlet av studenten, og vil bare være tilgjengelig for studenten og veilederen.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes 12.07.2020 og personopplysningene vil bli anonymisert og lydopptakene vil bli slettet på en sikker måte.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Tone Sze, masterstudent.
  Epost: _____, telefon: _____.

- Eirik Larsen Følstad, veileder.
  Epost: _____, telefon: _____.

- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Tone Sze	Eirik Larsen Følstad
Masterstudent	Veileder

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet forretningsmodeller for skivedeling i 5G, og har fått anledning til å stille spørsmål.

- ☐ Jeg samtykker til å delta i intervju, hvor det blir tatt lydopptak.
- ☐ Jeg samtykker til at informasjonen fra intervju kan benyttes av studenten.

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 12.07.2020.

_____, april 2020

Appendix B

Interview guide

Intervjuguide – Forretningsmodeller for skivedeling i 5G.

Intervjuobjektene velges ut fra snøballmetoden, hvor jeg starter å kontakte intervjuobjekter foreslått av min veileder. Gjennom disse kan jeg få tips om hvem andre jeg burde snakke med, dersom de selv ikke kan stille opp eller har noen andre som passer seg bedre. Intervjuene vil være semi-strukturerte hvor Business Model Canvas, en anerkjent forretningsmodell, brukes som et verktøy for å styre intervjuene i riktig retning. Formålet er å lage en forretningsmodell ut ifra informasjonen jeg får gjennom intervjuene.

Innledning

- Om min masteroppgave.
- Formålet med intervjuene.
- Informasjon om personvern og opptak av intervju.

Hoveddel, spørsmålsdel

Her er målet å få et faglig/objektiv perspektiv og ikke personlig informasjon.

- Tanker om teknologi rundt 5G og skivedeling.

- Aktører og roller i en forretningsmodell.
    - Hvem er aktørene i en slik modell.
    - Hvilken rolle vil aktørene ta.
    - Forskjellige vinklinger fra forskjellige aktører/roller.

- Hva er nytt med skivedeling? Hvordan er mulighetene i forhold til et nett uten skivedeling?
    - Fordeler for de ulike aktørene.
    - Forutsetningsmessing og bruksområder for de ulike aktørene.

- Teknologiske og regulatoriske forutsetning for skivedeling.
    - Begrensninger og utfordringer.

Avslutning

- Oppsummering, har jeg forstått det riktig?
- Hvordan intervjuet kommer til å fremstå i masteroppgaven.