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IMPROVING SERVICE SCALABILITY IN IOT PLATFORM BUSINESS

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ABSTRACT

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This thesis aims to improve the scalability of several case companies' business which offer their services through their own IoT platforms. The case companies are still in the early stages of their lifecycle, and their aim is to grow their businesses significantly in the future. Thus, enabling high scalability in service production is important for them.

A literature review was conducted to find the most critical factors that affect scalability of services that are provided through an IoT platform. Interviews with open-ended questions were used to determine the current state of the case companies regarding the factors that were presented by the literature review. Based on the literature review and the current state analysis, two productization models were created including commercial and technical portfolios. Resource drivers were also included in the models. The created productization models for IoT service offerings are suggested to ease sales item management and to clarify the service offerings for both the provider and the buyer. Further, linking the resource drivers to the processes needed to offer the services illustrates the needed resources in different service production processes.

The presented productized service models are one step that the case companies can take to improve their service scalability, but the models are not a solution to all scalability problems. However, similar models could be used in other companies that provide their service offerings through an IoT platform to improve their service scalability as well.

Keywords: service scalability, IoT platform, platform scalability, product management

TIIVISTELMÄ

Palvelutuotannon skaalautuvuuden parantaminen alustan kautta toimivissa yrityksissä

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Oulun yliopisto, tuotantotalous

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Tämän opinnäytetyön tavoitteena on parantaa alustatalouden kautta palveluitaan tarjoavien case yritysten skaalautuvuutta. Case-yritykset ovat vielä elinkaarensa alkuvaiheessa ja niiden tavoitteena on kasvattaa liiketoimintaa merkittävästi tulevaisuudessa. Tämän johdosta korkean skaalautuvuuden mahdollistaminen yrityksien palvelutuotannossa on tärkeää.

Kirjallisuuskatsauksessa pyritään löytämään merkittävimmät tekijät, jotka vaikuttavat skaalautuvuuteen alustatalouden kautta tehtävässä palveluntarjonnassa. Case yritysten nykytila analysoidaan avoimin kysymyksin suoritettavilla haastatteluilla, joilla pyritään selvittämään tekijät, joissa case yrityksillä olisi parantamisen varaa. Kirjallisuuskatsauksen ja yritysten nykytila-analyysin pohjalta luodaan kaksi tuotteistusmallia, joissa kaupallinen ja tekninen tuoteportfolio on eroteltu toisistaan, lisäksi resurssiajurit on kuvattu mukaan malleihin. Tuotteistusmalli helpottaa eri tuotenimikkeiden hallintaa ja lisää palvelun selkeyttä niin myyjän kuin ostajankin puolella, lisäksi resurssiajureiden ottaminen mukaan malliin havainnollistaa tarjoajayritykselle sen tarvitsemia resursseja eri palveluprosessin vaiheissa.

Työn loppupäätelmänä luodut tuotteistusmallit toimivat yksinä toimenpiteinä, joidenka voidaan nähdä parantavan case-yrityksien skaalautuvuutta, mutta ne eivät ole ratkaisu kaikkiin skaalautuvuuden ongelmiin. Samankaltaisia malleja voitaisiin kuitenkin hyödyntää muissakin yrityksissä, jotka tarjoavat palveluitaan alustatalouden kautta toimialasta riippumatta.

Asiasanat: palvelutuotannon skaalautuvuus, alustatalous, alustaliiketoiminnan skaalautuvuus, tuotehallinta

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ABBREVIATIONS AND DEFINITIONS

HW	Hardware
ICT	Information and communication technology
IoT	Internet of Things
NFC	Near field communication
RFID	Radio frequency identification
SME	Small and medium-sized enterprise
SW	Software

1 INTRODUCTION

1.1 Background

The word “scalability” is often connected to computers with multiprocessor systems and their performance (Abbot & Fisher, 2015; McSherry, et al., 2015). When searching for more recent articles with the word “scalability”, it seems to link to blockchain articles. The term itself has been challenging to define, some even suggest that the term should not be used because there has been no definition on whether a system is scalable or not. (Hill, 1990) Nevertheless, scalability has certain descriptiveness built into the term.

Service scalability is seen more challenging compared to scalability of physical products. Heskett (1990) explains this with the differences in value creation; in a product offering the value is created mainly with the outcome, the product, but in terms of service offering, the manner the value is created also has influence on the customer, meaning how the service is offered. This raises the question on how can a service offering be scaled efficiently if each offering requires a separate and unique customer contact that the customers view as an important part of the entire service offering? Maybe this means that the scalable service offering needs to be offered in a different manner.

Internet of things (IoT) is a network in which devices are connected to each other and can transfer and modify the data as desired (Gupta et al., 2017). This kind of a system enables new kinds of operations that can be used in numerous fields, ones that can be sold for example as services. An important aspect of an IoT solution is its scalability, meaning the ability to adapt to a growing amount of workload, which would preferably need no system reengineering and would be able to sustain high-performance levels (Gupta et al., 2017). This type of scalability would then enable growth with a good profit margin since the new customer adaptation would not take too many resources.

The usefulness of the IoT based solutions have attracted a lot of attention in the manufacturing industry and also in other industries. For example, there has been a growing need for smart condition monitoring to assist the predictive maintenance in the factory setting (Haltian & Wirepas, 2020). The case companies of this thesis focus mainly on that type of issues, by providing condition, quality, and process monitoring through IoT platforms. The case companies have customers all over the world and even more potential customers, hence the service scalability is an important factor in their operations because the aim is to grow the business. This is the case for most of other companies as well who wish to provide services through IoT platforms and hope to grow their business. This thesis attempts to find the key factors that determine the scaling potential of IoT service providers and tries to find ideas for improvement.

1.2 Research problem and objective

The purpose of this study is to identify the key factors that enable scalability in services that are provided through an IoT platform. The literature part of this thesis will address the IoT platform scalability in general, while the empirical part will focus on the case companies and their practices. The practices found useful and beneficial for the case companies can be adapted to other companies operating with IoT based services as well.

This study is based on three research questions (RQs), which are as follows:

RQ1: How can IoT platform-based services be scaled?

The answer to this question is given through the literature review presented in the next part of this thesis. The literature review will focus on earlier studies to form an understanding of the key components of service scalability especially for companies that operate with an IoT platform. The literature review will then act as the basis for the following parts of this thesis.

RQ2: What is the current state of the elements that would enable service scalability in the case companies?

This question is answered with the information gathered through interviews conducted with the employees of the case companies. The questionnaire used is built based on the findings of the literature review. With the gathered information, the current state of case companies’ operations, processes, and services are examined from the scalability viewpoint. The aim is to gain a general but precise view of the case companies regarding services and their scalability.

RQ3: How can the case companies scale their IoT platform-based service offerings?

The third question is answered in the latter part of this study. The literature review and case companies' current state analysis are combined to address the scaling potential in the case companies and to find possible actions to improve the service scalability through IoT platform in the case companies.

1.3 Research process

This study is structured in the following way (Figure 1.):

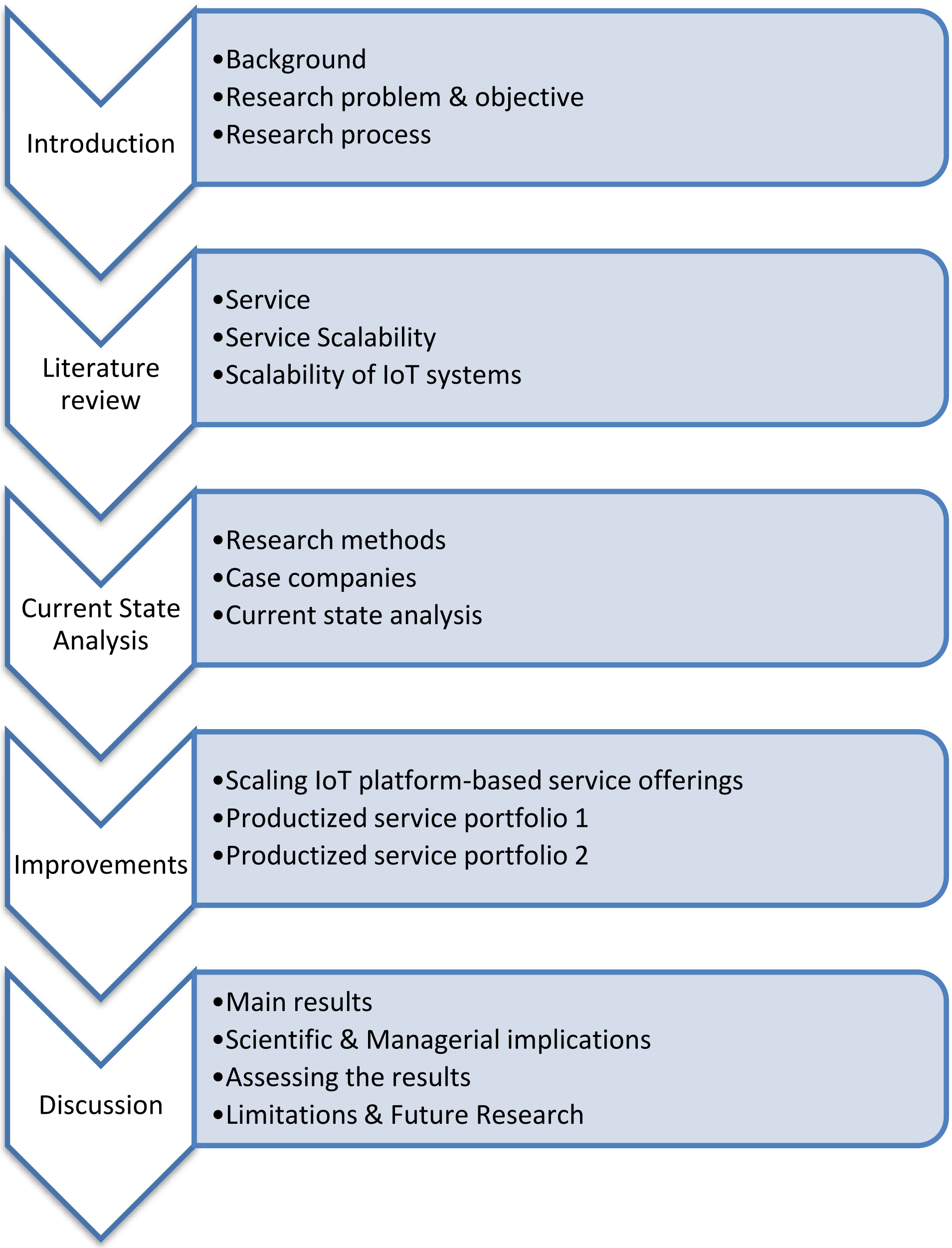

Figure 1. Thesis structure

First chapter of this thesis is the introduction, which presents the background and reasoning for this study. The research questions are also presented in this part. After the introduction, the study jumps to the literature review in which data are gathered from earlier studies. This literature review acts as the basis for the rest of the study by forming the background that can be relayed on. For the next chapter, the current state analysis, case companies' employees were interviewed via Teams. A total of six employees were interviewed from four companies. The companies, the interviewees, and the results of the interviews are presented in the current state analysis. The fourth chapter combines the literature review and the current state analysis to answer the question on how service scalability can be improved in the case companies. The last chapter is for discussion. In this chapter the results of this thesis are presented and summarised, also the implications of this study are discussed. Lastly the limitations of this thesis and future research possibilities are addressed in the discussion chapter.

2 LITERATURE REVIEW

This chapter discusses services, service scalability, and IoT platforms and their scalability by leaning on the earlier literature. The goal is to gain an understanding on the subject and to gain knowledge on how services can be scaled overall, and specifically in IoT platform ecosystems. The first subchapter discusses services in general to get a view on what providing services entails, what need to be taken into consideration, and how service offerings can be structured so that the service provision is as efficient as it can be. The second subchapter concentrates on the service scalability, answering the questions of what scalability is, and how services can be structured in a way that supports scalability. In the third subchapter the IoT platforms are discussed to explain what IoT and IoT platforms are. In the end of the third subchapter the 2nd and 3rd subchapters are combined to discuss the scalability of IoT platforms. The fourth and last subchapter is a synthesis of the literature review, which synthesizes the key concepts of the entire literature review and tries to answer the first research question: "How can IoT platform-based services be scaled?". The structure of the literature review is demonstrated in Figure 2.

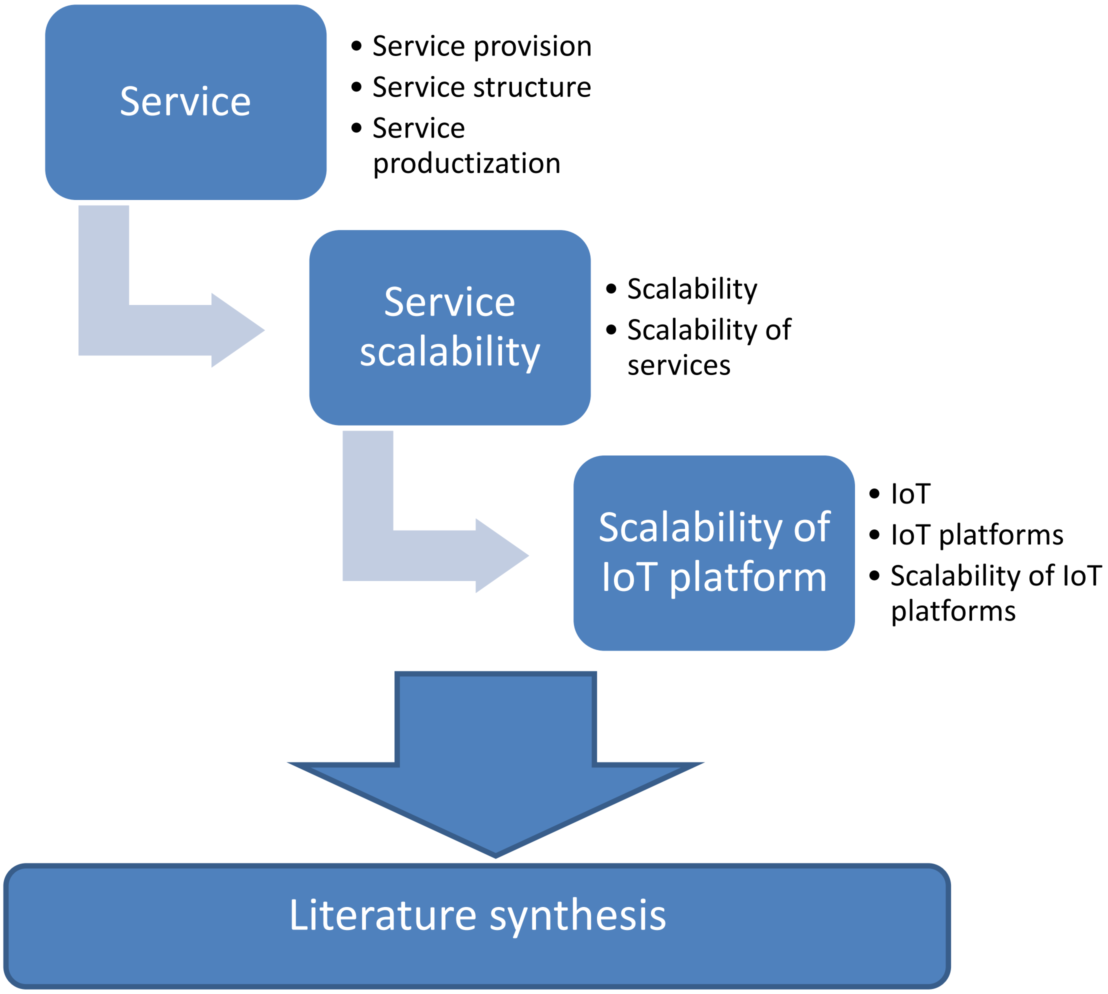

Figure 2. Literature review structure

2.1 Service

2.1.1 Service

In his 1982 article Lynn Shostack differentiated products and services with the tangibility of products that exist in a specific time and place when services are acts or processes that exists only in the time variable. He stated that products and services are very often linked together. When marketing a simple product, you are still often offering a service alongside the tangible product. So, you are actually selling a complex combination of products and services. (Shostack, 1982) Service is cocreation of value between customer and the provider. A service interaction consists of three parts. First is the proposal of value-cocreation, second is the agreement of the service and third is the actual service delivery, the realization of the proposal. (Maglio et al., 2009)

From the times of the Industrial Revolution, the main focus of nations has been the effectiveness in tangible product manufacturing. The exchange of goods has been the thing. Now companies are turning their focus from tangible products towards intangible offerings. Even though services were once just a side offer that could come with the tangible product it is now the core of the business. At the same time the focus has shifted from producer to customer. (Vargo & Lusch, 2004) The value of service received differs from the value of products. With a service the value consists of two parts 1) the results achieved and 2) the manner how they are received. These are measured from the customers' perspective. With a product it is enough that the product is good, but with services the service needs to fulfil the results demanded, and the process needs to please the customer. (Heskett, 1990, pp. 13-14)

There is evidence that service provision has gone too far with the process quality aspect. People are forgetting that the smiles are not enough, the service still needs to bring value to the customer. (Sewell & Brown, 2009) There can well be a measuring problem with the results of a service. For example, in education it is easier to say whether you like the teaching than what it is to evaluate your learning. This can be the reason why companies are concentrating on the delivered process rather than the results the process achieves. (Heskett, 1990, pp. 14)

The definition of service has changed over the decades. Shostack defined service as an intangible act that separates services from tangible products in his article in 1982. In their 2014 article Durst et al. defined services as "mainly intangible or knowledge products". Greer et al., (2016), on the other hand says that a service can be seen as a transcending concept in a business therefore it can be delivered face to face, intangibly, or through tangible goods. Maglio et al. (2009) defines a service as the application of resources to generate value for another. Nevertheless, researchers are underlining the importance of service regardless of company's line of business (Durst et al., 2014; Greer et al., 2016). Greer et al. (2016) states that managements have ignored the service revolution even though they should have adapted to it, and that companies should adjust their businesses towards services away from the product-based perspective.

Nowadays increasingly more service providers are aiming towards the internet and different kinds of applications with their service offerings (Elliott, 2002; Carlborg et al., 2014). Lund & Nielsen (2018) states that not a single real retail store is operating without some sort of internet platform to support its operations. Elliott (2002) gives an example in his patent document of a service system made for fast food drive-troughs. Customers' vehicles are equipped with radio-frequency tags and with those customers can therefore order and pay remotely. Only the pick-up takes place face to face. The service is faster and more efficient for both parties. On the other hand, this kind of internet-based services are not easy to launch, and keep up, due to the vast competition and constant evolvement in customer desires and technological possibilities. (Verganti & Buganza, 2005)

2.1.2 Service structure

A service system is an open system which mission is to create value for other systems through its resources. Service system is also capable of acquiring external resources from other systems i.e., finding value in its interaction with others. Combinations of single service systems can co-create a composite service system. These composite service systems have structures, which can be hierarchical, or market based. (Maglio et al., 2009) One of the first and most critical questions raised when implementing a service system is the structure of operations. In service provision there are usually more options on how to divide the tasks among workers and humans compared to traditional product-based operations. Also, the closeness to customers differs in services from manufacturing and results in the fact that ideas from manufacturing industry can rarely be directly used in the service industry. (Buzacott, 2000)

Service processes can be categorised in many different ways. The simplest model by Chase in 1978 article "Where does the customer fit in a service operation?" makes the classification in one dimension which is the degree of customer contact needed. (Buzcott, 2000) Two-dimensional classification can be made between the complexity and divergence of the process. Complexity meaning the number of steps needed to fulfil the customer's needs and divergence the variability of those steps. (Shostack, 1987) One option is classification along with the level of standardization of the service. The two dimensions being possibilities of customization and judgement calls from the service personnel. (Lovelock, 1983) Schmenner (1986) makes the two-dimensional classification with labour intensity and customer interaction compared with customisation. He criticizes Chase's model for being too simple because the amount of customer contact does not solely define a service. Comparing hotel and hospital service according to Chase they are classified near each other's but Schmenner sees a big difference in the customisation of these services, hospital management is more demanding because of the unstructured nature of customer contacts.

A company can influence their position on the lines of classification, and that will affect their business. Lower divergence usually results in cheaper operations, but it can also drive the customers away if they do not find the service suitable for them. Increasing the complexity can mean higher efficiency with scale advantages but it is harder to manage, and other firms can intrude with more specialized offerings. (Shostack, 1987) The same kind of balancing takes place between standardized and non-standardized services. Customized services are expensive, but they often also please the customer more than a same service fits all solution. On the other hand, if the standardized product is cheap, fast, and consistent it can fit many customers better than a custom made one. The same way some services need the possibility of judgement calls form the provider's side during the service although generally customers want to know beforehand what they are buying or signing for. (Lovelock, 1983)

Companies may need to make trade-offs with the structure of the service. The most important thing is that the service system matches with the customer requirements. A company can although choose its customers so a company can decide to minimize the variability of services, hence making its business more cost efficient and easier to handle. The customers that are not willing to pay for this kind of service can be excluded. (Buzacott, 2000) Basic and defined services are cheaper and easier to provide compared to additional services that might be needed occasionally. This is again balancing with the extent of the service compared to customer satisfaction which have been studied a lot in the past. (Li & Jiang, 2013) Shostack (1987) encourages managers to take a structural approach in their service offerings to increase control of the processes.

Classifying the service structure will lead to better understanding of the whole process. An option for this is a two-dimensional matrix where management can position their offerings. Figure 3. represents one possible matrix model. The best place to be in with service business is on the diagonal line. On the left side of the line the cost increases since the service structure is too complex for the use and in contrast on the right side of the line the service is too simple hence not fulfilling customer needs. Services tend to arise far from the origin and move towards it when maturing that is moving from flexible structure towards a more cost-efficient structure. (Buzacott, 2000) Van der Valk & Axelsson,

(2015) states that using different classifications together will lead to better results compared to individual classifications. Possible three classifications to be combined could be 1) “extent of customer contact”, 2) “degree of customization”, and 3) “degree of interaction/participation”.

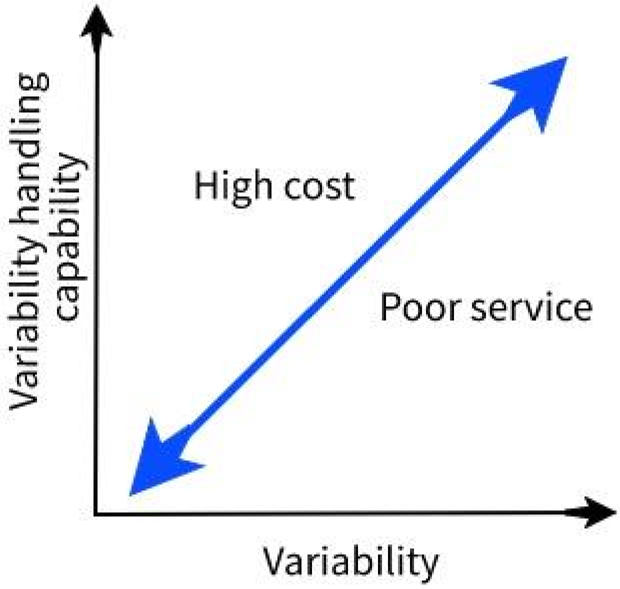

Figure 3. Service classification (modified from Buzacott, 2000)

2.1.3 Service productization

“Productization is the process of analysing a need, defining and combining suitable elements, tangible and intangible, into a product-like object, which is standardised, repeatable and comprehendible. Productization activities cover those for a product to be ready commercially, so it can be produced, delivered, sold, purchased and used.” (Harkonen et al., 2015) Ruohonen et al. (2006) define productization as the event of customized products getting a more standardized form. This takes place because companies are able to convert customized production into mass production to save money.

Valminen & Toivonen (2007) defines productization of a service as the act of developing systematised service offerings. This is the desirable state to improve companies’ competitiveness. This includes a ‘product-like’ definition of the process and the outcome so that the service becomes more visible and constant. Harkonen et al. (2015) points out that the important role of service productization is to clarify the service offering and thereby create understanding and improve repeatability of the service. Baines et al. (2007)

sees service productization as improving a service by adding a product or a new service component into the existing service which can be marketed as a product to the original service. Harkonen et al. (2015) recognised eight characteristics of service productization.

- “A process/development phase
- Standardisation/systematisation/better definition/reproducibility
- Making tangible
- Making something marketable/saleable/ready commercially
- Value creation
- Improving customer understanding/demonstrating value
- Packing to a form suitable for customers
- Defining offering based on needs”.

The aim with service productization is to improve competitiveness and performance. A company can cut its costs by systematising and defining the service because this makes service offering more efficient. It is also easier to calculate the costs of a single service when actions are systematic, this will help price setting for individual services. (Valminen & Toivonen, 2009) Jaakkola’s (2011) interviews point out that systematising and standardizing service offerings also help marketing. If a company has a prepared template for their offerings, it saves a lot of time from the marketing division. Although it is often talked about standardization in the context of service productization, Harkonen et al. (2017) states that the term refers more often to a degree of formalisation rather than full standardization. The level of formalisation depends on the productized service, but usually it will not reach the level of actual standardization.

According to Jaakkola’s (2011) interviews, the need for standardizing and specifying also comes from the customer perspective. A specific and standardized service is easier to sell and buy. The service should be so simple that customers have no challenges understanding it, and therefore have no hesitations or fear buying it. The customer should get a feeling that he gets something concrete from the purchase. On the other hand, it is vital that you identify customer needs before productising your service. You do not want to create a service product that does not bring value to customers. An option is to include customers in the productization process and convert customer information into customer understanding. (Valminen, 2011)

Service productization aids both the service provider and service management, but also customers. Systematising services aids the reproduction, and it can be done for example trough modularising the process. Tangibilising helps to understand the service and the process, which is crucial for both internal and external understanding. Formalising a service makes it more manageable and yet allow the service to meet different customer needs. (Harkonen et al., 2017) With well-defined processes it is also easier to monitor and measure the success and efficiency. Data gathered from well-defined processes also makes more sense, and it can be used to improve the services even further. (Jaakkola, 2011) Productization creates a "platform for common learning" in the company that will boost the company's valuable knowledge trough individual customer contacts. It will also promote the knowledge of employees. (Valminen, 2011) A productized service model is easier to learn by new employees as well. It is easier to learn a well-defined process compared to a model where every decision from the service employee is a judgment call. (Jaakkola, 2011)

Jaakkola (2011) also points out that productization of services does not lower the value for customers compared to tailored services, vice versa it will add value to customer. With a standardized process the company knows what to do and it will do it fast and efficiently. From the customer perspective it is also beneficial to have a better stability of the service offered. In addition, the purchasing side can compare different suppliers, their price, and the promised service to choose the best fit for them. (Valminen & Toivonen, 2009) One problem arises with customer attitudes for service productization. Company needs to focus on the interaction with customers so that they feel that their demands are being met in a proper way. Customers do not need a complete understanding of the service composition; it is enough that they will know what they are getting and what benefits can be expected. (Harkonen et al., 2017) One possibility is to split the service structure into commercial portfolio, which is visible to customers, and to technical portfolio, which can be hidden from the customer perspective (Mustonen et al., 2019).

Productized product or service can be fractioned into a hierarchical structure. On the top is the commercial side which can be divided further to levels, which are from top to bottom 1) solution, 2) product family, 3) product configuration, and 4) sales item. (Lahtinen et al., 2019) There can also be additional sub-product family layers if necessary (Mustonen et al., 2019). These layers are usually visible for the customers. The lowest level in commercial portfolio, involves the sales items, which can be hardware, software, services, or documentation. These sales items can then be combined to form product configurations, and further product families and complete solutions for customers. (Lahtinen et al., 2019) If the offering is a service the sales items are services out of which the customer can choose from. In this case, the physical products that are used are seen as resources rather than sales items. (Mustonen et al., 2019)

Under the commercial product portfolio is the technical product portfolio. The highest level here involves the version items, which are then linked upwards to sales items. Version items are created when an old product is modified in a way that the product's fit, form, or function do not change. These version items consist of assemblies, usually main assembly, and subassemblies. The lowest level of subassemblies consists of components, which is the lowest level in the productization product structure. The modularisation of products stem from the technical side of the productization. (Lahtinen et al., 2019) If the solution offered to customers on the commercial side is a service, the technical side is a bit different compared to a physical product-based offering. The assemblies for products are processes for services, and components are tasks. These needed tasks require certain resources like human working hours or machine hours, which can be added in the productization matrix under the task level. The main logic behind the productization is still the same between service offerings and product offerings. (Mustonen et al., 2019) The commercial and technical product portfolios are illustrated in Figure 4.

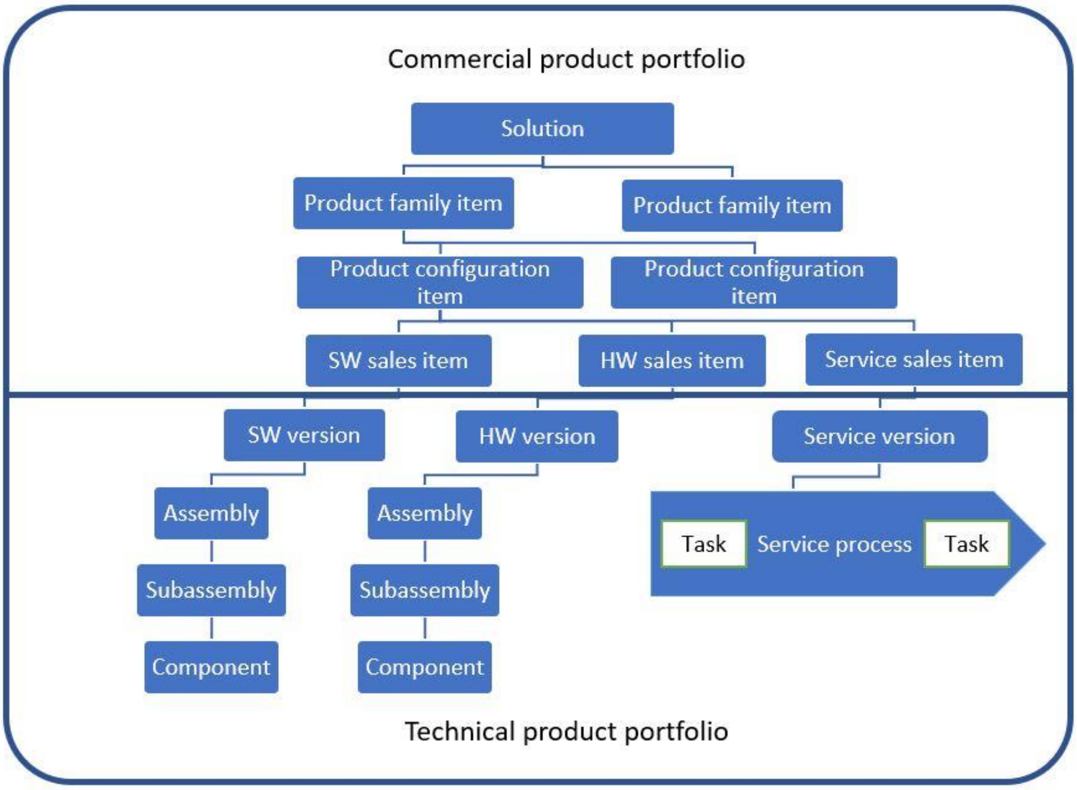

Figure 4. Product portfolio structure (modified from Lahtinen et al., 2019)

Modularity is seen as one of the key concepts of service productization. Modularisation is seen to help with service offerings in manageability, pricing, and communication with customers. (Harkonen et al., 2017) Service modularisation is the act of structuring services in different modules that have clear boundaries and that have been planned beforehand in a formal architecture. Modular structure gives options for management since they have many small components that they can use and combine compared to a non-modular structure with one composition of service offering. (Baldwin & Clark, 2002) Pekkarinen & Ulkuniemi (2008) divided service modularity into three different segments: modularity in services, modularity in processes, and modularity in organisations. All of these need to be considered and identified. A service consists of one or more service modules, it is done through one or several process modules in organizational modules.

Productization of a service is done by associating tangible parts in the service offering. These parts can be methodologies, collaterals, facilities, and other attributes. (Chattopadhyay, 2012) Jaakkola et al. (2007) divides the productization process in five stages: evaluation, definition, standardization, concretisation, and pricing. Valminen & Toivonen (2007) adds three stages in Jaakkola et al.'s process these are marketing, protecting, and piloting the service. These should be done before implementing the productized service. Valminen (2011) divides organisational tasks in five parts in service productization. The first one is concept creation where the customer needs and the service are identified roughly. In the second part the content and structure are defined more specifically including price, market, and competitors. Third part is for defining the service process meaning employee responsibilities and roles in all stages of the service. The second to last part is for competence mapping: defining the need for additional resources. In the last part company builds an evaluating system so that it can monitor and measure its success.

2.2 Service scalability

2.2.1 Scalability

Hill tried to define scalability in his 1990 article. He wrote that scalability measures the change in efficiency when the number of processes or “problems” increase. The problem was that he could not determine when a system is scalable and when not. He wrote “I assert that calling a system "scalable" is about as useful as calling it "modern". I encourage the technical community to either rigorously define scalability or stop using it to describe systems.” (Hill, 1990) Lund & Nielsen (2018) uses the term to indicate that a change in size is achievable. Bondi (2000) defines system scalability as the ability to adapt to a growing number of objectives, increasing amount of work or enlargements. Yaqin et al. (2017) adjusts system scalability to business process scalability as an ability to endure a growing number of processes or allow the business process to enlarge.

Unscalability is mostly referred to systems where an increase in size, work, or traffic leads to excessive additional costs or is just unable to grow at all in any parameter. Trying to grow this kind of business or system increases costs or harms the quality of services offered. (Bondi, 2000) Brad Hargrave from General Assembly questions the concept of unscalable businesses in an interview. He states that businesses are scalable even though they are referred as unscalable. People just say something is unscalable when they are meaning that it is hard and complicated to scale. (Guo, 2016)

Scalability is the main attribute determining the possibility of growth in a company. This leans on the assumption that different revenue sources are created with different costs. (Jabłoński, 2016) Poor scalability of a network, system, or process can lead to reengineering and overlapping work hence scalability is so valuable (Bondi, 2000). Lund

& Nielsen (2018) underline the importance of business scalability to several stakeholders. Societal wealth trough job creation which also increase tax payments. Investors like to invest in scalable companies because of the good growth outlooks. In the same way, employees are happy to work for a business that can scale and grow and therefore have for example a lower risk for layoffs.

Scalability links to performance when the load of a system is increased. Performance measures the speed and efficiency of a system while scalability measures performance changes when the volume or workload is increased. (Khare et al., 2012) To be able to evaluate the scalability of a system, the performance needs to be measured before the increased workload, or system size, and after it (Lee et al., 1998). Scalability enables companies to maintain their high performance in a long run and therefore helps companies to build a sustainable business (Jabłoński, 2016).

Scaling can be either vertical or horizontal. If thinking as servers, horizontal scaling means new servers next to the original ones, and when scaling vertically more cores are added to your existing serves. (Garcia et al., 2008) In a company perspective vertical scaling means the actions of adding more components to the business model of a company. In horizontal scaling the expansion happens outwards new companies are added and embedded in the network thus creating a new bigger network. (Jabłoński, 2016)

Jabłoński (2016) defines four different levels of scalability. The most scalable is super-linear in which performance grows faster than the business around. The second one is linear scalability where performance values are growing linearly with the business model. The scaling's effectiveness is therefore 100%. In sub-linear scaling the business grows faster than the performance increases, but the performance is still rising. Negative scalability is the level of non-scalability. An expansion in business model leads to lower performance. Lund & Nielesen (2018) make the division into three groups, declining, constant, and increasing return to scalability. The return to scale being declining means that an investment of 10% will give you under 10% net result increase. Constant return to scalability gives you 10% on the same investment while an increasing return on scale gives a company an over 10% rise in net result. They further divide the declining and increasing return to scale in linear and exponential attributes. Exponentially increasing being the sweet spot you want your company to be in and exponentially declining is where a company needs to get away from as quickly as possible.

2.2.2 Service scalability

There is a major difference in scalability between products and services. Scaling production have been a goal for us since the Industrial Revolution, and it can be seen as a mastered skill with all kinds of techniques like concurrent manufacturing, computer aided design, and computer aided manufacturing. Services are different and harder to scale. Each customer is unique and since a service is about value co-creation between provider and customer, the service usually needs to differ between different customers. (Hsu & Spohrer, 2009) Morelli (2015) states that when implementing a service, the scalability factor should be taken into consideration in the first phase. The system needs to be structured so that it can be scaled.

In their article in 2003 Kuusisto & Mayer stated that an increasing amount of attention is flowing towards scalability of services. Advanced firms have been concentrating on this subject for years for now and it is coming a common practice. Kindström & Kowalkowski in their 2009 published article still ended up in the conclusion that service providers are not putting enough effort in the development of the service to end up with tangible and scalable services that are easy to commercialise. At the same time, they admit that services that are not served with information and communication technology's (ICT) help are very human intensive and therefore hard to scale cost effectively. (Kindström & Kowalkowski, 2009) For example a consulting company's business, which resources are nearly merely human working hours is not really scalable as such. Increase in workload results in an increase in manhours which again increases costs. To be scalable a company needs to find synergies in their offerings. (Lund & Nielsen, 2018) It is rare for services to be scalable as such, as it often requires at least some level of modification between different customers. Therefore, scalability of services will be slower compared to product scalability. (Kuusisto & Mayer, 2003)

One option to tackle the challenge of service tailoring between customers is productization of service offerings. Services are usually intangible and abstract which makes it hard to get a grasp on them. Productization makes services standardized, more tangible, more understandable, and repeatable. (Harkonen et al., 2015) As in any other line of business the standardization of models in service business is important to be able to scale the business (Eaton et al., 2011). Repeatability is also one of the key components when aiming towards a scalable service offering. It also helps the service business elsewhere. A repeatable service is more predictable and easier to assimilate by employees, which again reduces training time. (Chattopadhyay, 2012) New employer training is a big part in a growing company, a well-defined productized service model is easier to adopt by new employees. This is crucial for the ability to scale the business. (Jaakkola, 2011)

One part of service productization is service modularisation (Harkonen et al., 2017). With service modularisation the service offerings can be divided into smaller modules that are easier to manage. These modules can then be combined in different combinations to form various service assemblies. (Baldwin & Clark, 2002) This is important to meet different customer needs (Tyler et al., 2007). It has been recognised in several papers from different service sectors that modularisation helps the scalability of services with the segmentation of service elements (De Albuquerque et al., 2005; Pohjosenperä et al., 2019; Pekkarinen & Ulkuniemi, 2008).

Services can be scaled with different kind of models and dimensions. Nielesen & Lund (2018) points out four dimensions how service offerings can be scaled. These are:

- Enriching value proposition
- Removing capacity constraints
- Developing a platform
- Involving stakeholders in the business model (Nielsen & Lund, 2018)

A good value proposition is important for any kind of a firm. It is the key for a long-lasting profitable business. A service company needs to truly understand the value they bring to their customers so that they can optimize it in an even greater manner. It is the key to exponential scalability as pure cost cutting is not leading to that. Real and unique value offered to customers and partners will strengthen the co-operation and cause long lasting both ways beneficial relationships. (Nielsen & Lund, 2018) Pursuing this will often lead to balancing between the actual scalability of the business model with scarce resources and the value created to customers. It will often need a new kind of invention, which can include for example automated stages in service offerings. (Hallowell, 2001)

The ultimate scalable service offering would be something that does not have physical constraints like money, man hours, machine hours, storage room, and such, and at the same time is a unique value proposition which is hard to copy by competitors. Company needs to be able to remove the capacity constraints in their service offerings. (Nielsen & Lund, 2018) Paina & Peters (2012) say that a part of scaling a service is to strengthen the capacity of the delivery of the service. For service businesses human working hours is often a big expenditure and since involving variable costs is a constraint for scaling (Hallowell, 2001). The chance a company needs to make is to tackle the capacity constraints to chance the service model from selling human working hours to selling data of some kind. Instead of customized work company should offer standardized services in a product like format. (Nielsen & Lund, 2018) This is although hard since many service providers rely on human resources to offer high-standard services (Hallowell, 2001).

Another need for exponentially increasing scalability of a service is the creation of a platform. In an optimal scenario this would mean that your service business acts as a platform for other businesses, it could even make a competing firm to become your client. (Nielsen & Lund, 2018) Amazon is an example of this transformation. They managed to develop such a good platform that competing smaller online retailers became their customers when they started to sell their products through Amazon's online platform. This can be seen also the other way around. The platform to scale on does not have to be developed by the service provider itself, the provider can also use an existing platform. (Smedlund, 2012)

As pointed out earlier a big obstacle for service scalability is funding. Scaling up a service usually requires a significant increase in resources, although the resources are expected to be used in a more efficient manner after the scaling. (Eaton et al., 2011) If a company can outsource some of its tasks to other stakeholders, like customers or partners without paying by involving them in the business, the business is a lot easier to scale. To be able to do this, the stakeholders will of course need to benefit from their work by themselves too. (Nielsen & Lund, 2018) Banks are a good example of this. In the past bank's employees managed the transactions of their customers at the bank but now customers can pay their bills by themselves anywhere through bank's ICT platform. This demands some level of ICT competence by the customers, but it will save a lot of manhours from banks. (Smedlund, 2012)

2.3 Scalability of IoT platforms

2.3.1 IoT

People are using increasingly more electrical devices in their everyday life. These devices are connected mostly via internet and are communicating with each other. Anything in the physical world can be connected to the internet and all of us need to adapt to this revolution. (Holler et al., 2014, pp 3-9) Alessandro et al., (2014, pp. 2) claim that Internet of Things (IoT) is something we are not experiencing as such. It will just reshape our lives and actions by connecting our objects together. IoT is taking our technology from human to machine interaction towards increasing machine to machine interaction. This will save time of human workers since they do not have to intervene in every part of the process. (Kumar & Mallick, 2018)

It is widely recognised that the term Internet of Things was coined by Kevin Ashton in 1999 while working for the company Auto-ID (Ashton, 2009; Madakam et al., 2015; Suresh et al., 2014). The concept itself dates a lot further at least to 1982 when sensors connected to the internet predecessor were attached to a coke machine to report if there was any soda left and if it was cold (Farooq et al., 2015). Ashton (2009) describes the term Internet of Things as the possibilities of the internet when connected to things, meaning all kinds of devices. In the past computers were nearly fully dependent on the human interaction, humans needed to feed them information. With IoT and, for example sensors, machines can observe by themselves without human intervention. This will mean a lot more data gathered while also saving time of humans.

There are also many other definitions among experts and researchers on what IoT is. According to Aggarwal et al., (2012) IoT is a global network that enables connection between humans and things in all three combinations: human – human, things – things, and human – things (Madakam et al., 2015). Suresh et al., (2014) summarise IoT in a phrase simply as “connection between humans – computers – things”. Internet Architecture Board defines IoT as the enabler of Internet Protocol usage of a large number of embedded devices that are not directly controlled by humans. The large number of different explanations for IoT does not mean that there is a disagreement. Instead, it just describes how large the concept of IoT is. Different definitions merely illustrate different aspects of the concept. (Irmak & Bozdal, 2018)

The number of IoT devices world-wide is enormous. Statista Research Department estimated that there were 22 billion connected devices world-wide by the end of 2018. (Statista, 2019) This is quite a lot since in 2017 there were estimates of 20.4 billion devices by 2020 (Berte, 2018). There might of course be some differences in the calculation styles. Most of the devices deployed are for consumer use like smart TVs, fridges, and vehicles. These consumer devices account for, and have accounted for, easily over 50 % of the new devices every year. For businesses, the most common devices are different kinds of electric meters and security equipment. (Tung, 2017) Berte (2018) states that for consumers the concepts of IoT and smart homes are the same, but IoT is seen as a strange and scary term. A company that was offering security solutions for homes could not name their services as IoT security because consumers did not like that. They were rather named Smart Home security solutions. Berte thinks that the term IoT is connected to the concepts of machine learning and artificial intelligence and is therefore easier used in business world. (Berte, 2018)

IoT systems can be utilized in a vast number of fields from smart homes to traffic routing and pollution monitoring (Yelamarthi et al., 2017; Malek et al., 2017). The basics involve giving things the power to observe their surrounding environment and to transfer this gathered data forward, and to perform tasks with this information. This is possible with sensors, communication devices, and computing equipment, which are the key parts of a IoT platform. (Yelamarthi et al., 2017) With IoT we can cut our costs and improve our efficiency in different kinds of environments all over the world (Berte, 2018). The large scale of possibilities with IoT systems are illustrated in Figure 5.

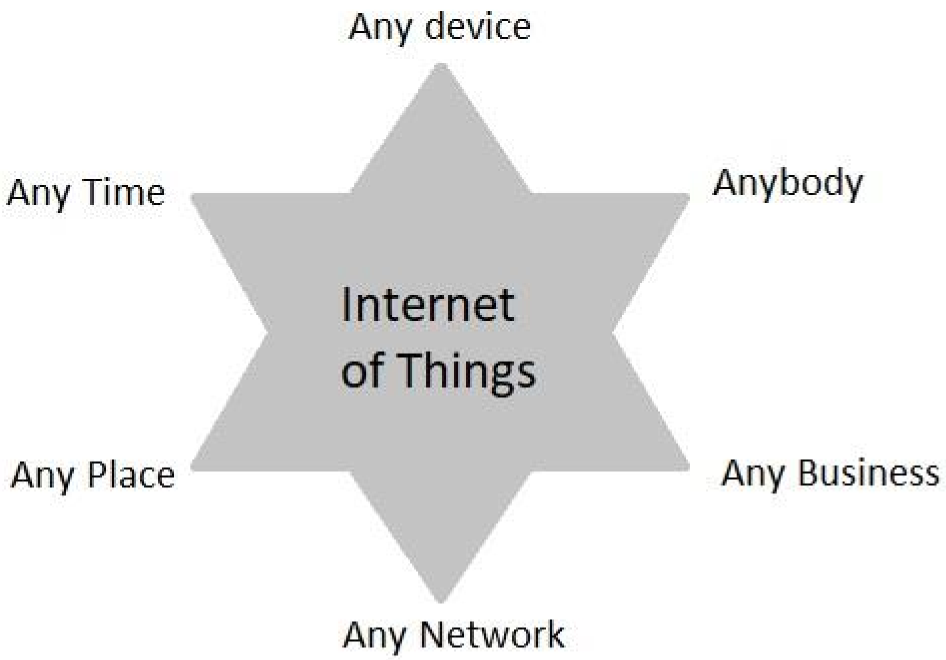

Figure 5. Internet of Things overview (modified from Pratap, 2016)

2.3.2 IoT platforms

Platforms are vehicles that able distinct parties to generate value to each other (Evans, 2009). Most of these are digital and use the internet to transfer data between users. Platforms can be divided into two groups based on the way they create value to their users. Transaction platforms handle transactions between distinct parties, for example Uber and Ebay are this kind of platforms. The other type of a platform is innovation platform. An innovation platform acts as the foundation for innovations by others, Google Play store is an example of this. (Evans & Gawer, 2016) This new style of economy has been named as platform economy (Montalban et al., 2019).

IoT platform is a software that combines the "things" together in the IoT world. It is a transversal middleware behind the actions that are done with IoT solutions. (Trilles et al., 2020) The platforms are mostly cloud-based meaning that all the IoT parts are connected to internet and are communicating with each other through the internet. These parts can be gateways, sensors, users, and the platform itself. The other option is a local platform where the platform is in the middle of things. Sensors, gateway, internet, and user are connected directly to the platform. These different designs of the platform model are referred as platform architecture. (Mineraud et al., 2016)

There is no one specific architecture that would be accepted and kept as the best option in IoT systems. Also, because of this experts and researchers are creating their own platforms that suit their needs. Already in 2016 there were over 360 IoT platforms created. The main architectures that are in use consist of three or five layers. For three-layer systems the layers include: perception layer, network layer and application layer. The additional two layers for the five-layer architecture are processing layer and business layer. (Irmak & Bozdal, 2018) Nevertheless, four, six, and seven-layer architectures are also presented in the literature (Kumar & Mallick, 2018; Verma et al., 2018). The number of layers depends on the terminology used (Krčo et al., 2014) and the needed features. More layers mean greater complexity and harder integration but also grater possibilities. (Kumar & Mallick, 2018)

One layer that all the IoT architectures have is the communication layer (or network/transmission layer), which transfers the data between things (Kumar & Mallick, 2018). The connections between things can be executed either with wired connection or wirelessly, the latter one is preferable due to the easier and cheaper installation (Suresh et al., 2014). There are various options for wireless data transferring in IoT like Bluetooth, Near-field communication (NFC), Radio-frequency Identification (RFID), and Wireless Sensor Networks. Some of these individual communication types can then be divided further into subtypes, for example RFID into four different types according to the used frequency. (Khanna & Kaur, 2019) These technologies differ for example in power consumption, signal strength through objectives, for example walls, signal range, and bandwidth, so the best option depends always on the needs of the user (Perles et al., 2018; Khanna & Kaur, 2019).

Other necessary layers of a IoT platform are perception layer and the application layer. Perception layer's role is information gathering. (Kumar & Mallick, 2018) It can consist of sensors and/or actuators. These sensors can be monitoring nearly anything like temperature, pulse, wind speed and direction, soil moisture, etc. (Yelamarthi et al., 2017) This gathered information of the environment is then transferred further through the network layer. In more complex architectures there might be a processor as the next step in the chain. This additive layer can for example filter the data gathered before sending the data to network layer. (Kumar & Mallick, 2018)

Application layer is the last layer of a basic platform structure. It is responsible for providing the access to the gathered data for the end-user. This might include data storage, visualisation, and analytics to provide the best possible information to the user in an understandable manner. (Yelamarthi et al., 2017) There can be several applications for different fields (i.e., finance, logistics, media etc.) in one IoT system's application layer. These applications can work individually with own sensors and actuators which are working in the same IoT platform with other applications. (Irmak & Bozdal, 2018) An application can also be a self-reliant actor and work without an end-user. It can be programmed to do certain tasks when getting certain data from the actuators or sensors via network. (Guth, 2018)

2.3.3 Scalability of IoT platforms

Internet of Things' scalability refers to the ability to meet the changing needs of the environment. This is crucial for a system that should be able to master an increasing amount of work. (Gupta et al., 2017) Also, Liu et al. (2016) assesses that Scalability of IoT platforms does not only mean the ability to expand a system but to elastically adjust operations and resources to the actual demand at a specific time. Efficient resource allocation will help the system to survive the changing needs in the future as well.

An IoT platform should support as many devices and applications as possible and be able to handle complexity and different amounts of workload. This can mean for example that a system can use same hardware for different tasks, which will lead to flexibility and scalable system. (Macaulay, 2017) Oueslati (2020) breaks IoT scalability in three parts: Technological aspect, costs aspect and data sharing aspect. Technological meaning the devices connected to the system. The second aspect states the importance of profits while IoT is just a tool to reach them. The system needs to be efficient and provide income. Third part underlines the importance of collaboration between different ecosystems, the platform needs to be flexible in that sense to be able to scale.

In IoT scaling can be made either vertically by adding more capacity to existing hardware or software or horizontally by adding more hardware or software to the existing system. The idea of both is to manage the greater demands with a more capable system. (Gupta et al., 2017) Different stakeholders are aiming for different goals with a IoT platform and due to this there is always a trade-off needed between horizontal and vertical scaling. For the platform owner the horizontal scaling would often be ideal because of better scalability with for example component reuse. Vertical scaling is more of a customer-oriented aspect. It limits the possibility of features that are not actually needed. It is also more flexible from a single customer perspective. (Schermuly et al., 2019) Vertically scaled system is more power efficient and does not need as much management with a more centralized system compared to horizontally scaled system. The weakness with centralization is of course the fact that all eggs are in one basket. A failure in a component will lead to bigger issues. (Gupta et al., 2017)

Oueslati (2020) would start an IoT project from the device level rather than from the cloud. He states that devices are the key for efficient and standardized services. Intelligent and efficient data handling by devices enable scalable IoT platforms. Gupta et al. (2017) points out the identification of the IoT devices. Even when there are millions of devices connected to the internet all of them need to be identifiable. Another aspect is the security of the data. If the data is sensitive, it should be encrypted before it leaves the device. This might at least be the case if there are devices from different parties connected to the same ecosystem. This all needs to happen on the device level of the system. (Gupta et al., 2017)

Along with the devices also the marketing capability needs to be taken into consideration when building a scalable IoT system. The system should be able to work in any environment so that it can be used by a large scale of customers. It should also be easy to use and allow some level of reforming of the system to fit well in different organisations. (Gupta et al., 2017) Pauli et al. (2020) although found out that in B2B context the one-size-fits-all model with an IoT platform is not enough. Platform providers need to make individual offerings for individual customers which of course hurts the scalability of the business.

The objective of a scalable IoT system is to be able to meet the continuously changing demand. People will always improve and change their preferences and wills and a great IoT system is able to meet these evolving demands. This added to the need of increasingly more devices connected to an IoT system rising several concerns about the ability of an IoT system to handle the ever-increasing amount and ever-changing type of workload. (Gupta et al., 2017) When designing a device or software for IoT usage the developer should always consider all the possible uses for one certain item. Never should a component be designed to work just for one purpose in an isolated environment because that makes the scaling harder in the future. (Macaulay, 2017) Also the data should be in an adequate and standardized format so that it is interoperable in different systems. This will also make the automated reasoning by the systems themselves possible in a wider scale. (Miorandi, 2012)

When planning a scalable IoT platform, designers should always take into consideration the things that have not yet been imagined but might be part of the platform in the future. This includes for example security and interoperability. A device can be working well in an isolated environment but when expanding operations, it could be useful that the device would be useable also in an open and not so secure environment. If the device were designed to work also in such conditions no redesigning would be necessary. (Macaulay, 2017) In an interoperable system, actors can have several roles for example data provider and data consumer. These can change over the time and even between different short-term situation. (Sarkar et al., 2014) Devices might also need to be connected in other devices or systems from completely different industry. These kinds of future possibilities should be taken into consideration when designing IoT systems and its actors. (Oueslati, 2020)

2.4 Literature synthesis

Usually, services differ from physical products by intangibility. Maglio et al. (2009) defined service as value cocreation between a customer and a provider. This process consists of three parts, which are proposition, agreement, and delivery. Since services are intangible the value created to customer is based on different factors compared to physical product offerings. Heskett (1990) states that the value of a service is based on two factors: the results received, which is similar to a product offered, but also the way the offering is executed. When buying a car, the customer is usually happy if the car is nice to drive and free of troubles, but when buying for example educational services, the customer probably wants to learn but also wants the education to be interesting and pleasant.

The most important thing with a service offering is to match it with the customer requirements. A company needs to create value to customers as otherwise the business will not succeed. The offered services cannot be too complex because it makes them hard to manage and often expensive to offer, but a too simple solution can lead to unsatisfaction among customers and is therefore bad business as well. This leads to constant balancing with the complexity of service offerings. One tool that can help is service productization.

Productization of services is the act of modifying a service offering into a product-like format. A productized service is clearer and more understandable for customers due to the product like and well-defined format, but also more repeatable, easier to price and market by the provider since the steps needed for a certain service are clear and systematised. With well-defined processes and outcomes, it is also easier to monitor the success of the service offerings. So, it can be said that a successful productization process aids both the customer and the provider.

Modularity is a key part of service productization. Service modularisation is the act of structuring the operations in small well-defined modules that can then be combined in different combinations i.e., service offerings, to achieve customer satisfaction. According to Pekkarinen & Ulkuniemi (2008) modularity is needed in an organisation at service level, process level and organizational level. Organisation should be structured into modules that have different responsibilities. These organisational modules entail process modules that produce service modules, which can then be combined in complete service offerings.

Productization and modularity can be improved by utilizing a consistent and common service structure that acknowledges the commercial and the technical side of the offering. The commercial side consists of the offering that is visible to the customers and can be bought. The levels on the commercial structure can include solutions, service families, service configurations, and sales items. The technical side of the offering consists of those elements that are used to produce the service, and can be structured as version items, service processes, service sub-processes, and individual tasks. The resource need of producing a service can be calculated by linking the technical service processes to the resources through resource drivers based on how much resources they use.

If a service organisation wants to grow its business profitably it needs to be scalable. Scalability of a company can be measured with performance metrics when increasing the workload, size, number of customers or similar. A scalable company can retain a high level of performance with increasing demand, thus enabling itself to sustain a profitable and growing business. Scaling can be managed either vertically or horizontally. Vertical scaling (scaling upwards) happens by improving the current system or operations, while horizontal scaling (scaling outwards) happens by adding more systems or operations next to the original ones (Jabłoński, 2016).

Service scaling can be handled through different routes. One scalable business model that is experienced as functional is the platform economy. Many big and profitable companies provide a platform for distinct groups to match their needs and transfer data. The fee the platform provider charges do not need to be big for the company to be profitable if the platform has millions of users, as for example Airbnb. The goal for a business, would be a service offering with no physical constraints (working hours, money, storage room, machine hours, etc.) and a unique and high value but hard to copy value proposition. This kind of service will attract customers, and the provider can handle the increasing number of customers with its near limitless business model yet being covered by competitors.

IoT platform, which is defined as a software that combines things together (Trilles et al., 2020), is a great tool to use when aiming towards scalability in service provision. There are still numerous factors that need to be taken into consideration when building an IoT platform economy. These factors include the value proposition for customers and the design and features of the platform. A service needs to create value for the customers, while a platform is a good tool to transfer the value, but the service provided through the platform still needs to be of high level. The service should be productized, and both the service and the processes should be modular for better manageability of processes for the service provider, and easier understanding of the services offered to the customers if favourable. Nevertheless, no platform alone will change a bad service to a great service.

The other factor that needs to be taken into consideration, is the usage of the platform. A platform provides great potential and vast number of options to play with, but the service provider needs to take advantage of these possibilities. These actions could include, for example, making other stakeholders do some of the needed tasks, these stakeholders can be customers, partners or even competitors. A company can also get rid of capacity constraints with platform usage; by selling a predefined platform service the business can be very scalable since adopting new customers is easy. One key transformation a company needs to make to be highly scalable is to transfer the sold service offering from selling human working hours to selling data. The last thing that needs to be taken into consideration is the future of the operations. To be scalable the platform should be flexible for future needs; this includes being able to connect to other distinct platforms, so that the platform can be a part of a bigger platform economy in the future. Figure 6. illustrates the dimensions of a scalable IoT platform economy.

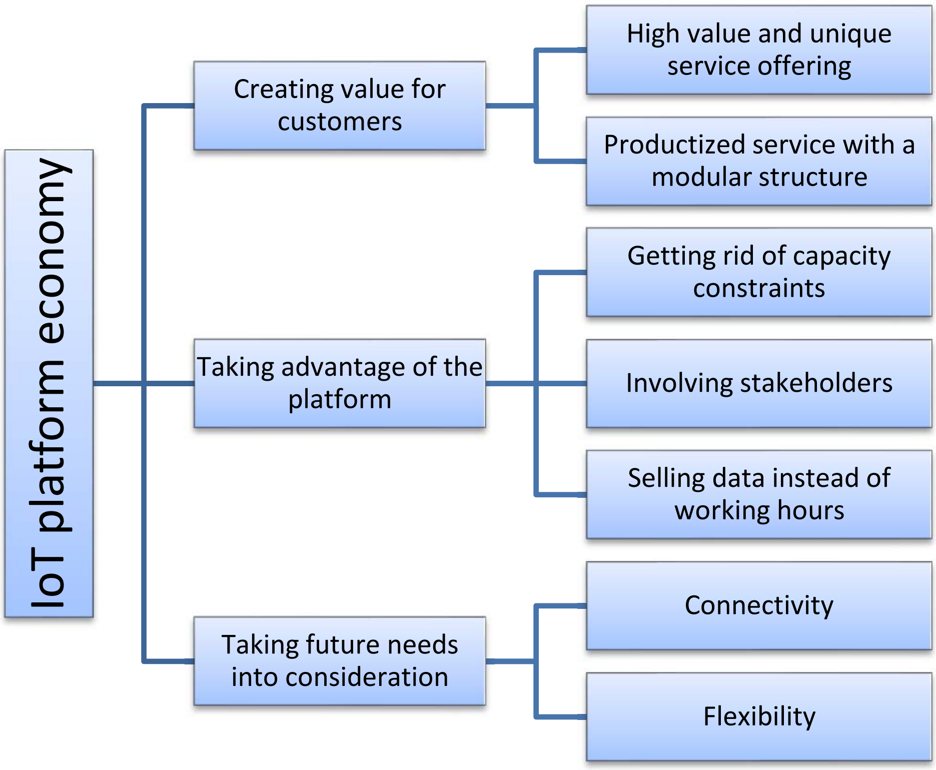

Figure 6. Elements of Scalable IoT platform economy

A well-structured service offering built on an IoT platform can be very scalable. The platform reduces man hours needed by enabling machines do the work of humans by communicating together and doing predefined tasks. Productization with modular structures of the service offerings and the processes maintained to produce the services brings understandability, visibility, repeatability, marketability, constant and good quality, and better view on the price the service offering can be sold for. If the service provider also takes the future possibilities and obstacles into consideration beforehand and is ready for them a company is ready to scale and grow.

3 CURRENT STATE ANALYSIS

3.1 The research method and the case companies

The current state analysis was carried out via semi-structured interviews (Farquhar, 2012) in four case companies. The questions (Appendix 1) were open-ended except for a few questions that could be answered with a "yes" or "no" answer, although if the response would be that simple, further questions were asked to get an explanation for the given "yes" or "no" answer. The questionnaire followed the following structure: basic information, service productization and modularisation, scalability, IoT platform, and upkeeping.

The goal of the interviews was to acquire information about the current state of the case companies' offerings, their scalability, and the companies' IoT platform business, to gain the answer to the second research question: "What is the current state of the elements that would enable service scalability in the case companies?". The questionnaire was identical for all the interviewees even though not all questions were relevant for all of the companies nor for all of the interviewees. The questions were not modified for single interviewees regarding their responsibilities and areas of competencies to acquire different viewpoints within a single company. The questions were neither modified for different companies as before the interviews were conducted the knowledge of the case companies, their operations, and services offerings were not completely clear. Some questions were skipped or modified because of this during the actual interviews. A total of six interviews (Table 1) were conducted to gain an understanding of the current state of the case companies.

Table 1. The case companies and the interviewees.

Company	Company size*	Company description	Role of the interviewee
Company A	Small	Offers quality and process monitoring	Sales director Chief metallurgist
Company B	Micro	Offers process monitoring and optimizing	Head of research Sales development manager
Company C	Micro	Offers continuous condition monitoring	Chief operating officer
Company D	Small	Offers IoT tracking devices	Head of business development
*According to the definition of the European Commission (2021)			

All the case companies in this study are small or micro-sized enterprises employing permanently less than 20 people. These companies offer various services through their own IoT platforms that enable data gathering, storing, visualisation, and analysis. The companies, their offerings, and the role of the interviewees are presented in Table 1.

Company A

Two persons were interviewed in separate interviews from company A: sales director and chief metallurgist who is also responsible for the innovations and research. Together they gave an explicit picture of the offerings the company offer, and the processes needed to produce them.

Company A offers quality and process monitoring services for metallurgical industry purposes. Their offering consists of hardware items and the platform in which the hardware items can be connected for visualising, analysing, storing, and sharing the gathered data. The services are offered with three different hardware items that can be further modified into dozens of individual solutions. Customers can choose the hardware items according to their needs, and the result will be a certain number of hardware items, usually with some level of customisation, which are then linked to one platform in which all the data can be accessed. The platform is easy to use and enables real time data that will be widely available in the customer organisation.

Company B

Company B offers process monitoring and optimizing services to their customers who operate in metallurgical industry and more specifically mainly as steel producer. The head of research and the sales development manager were interviewed for this thesis in separate interviews.

Company B sells monitoring equipment as products but also process monitoring as a service. The service package always consists of hardware and software. Hardware items are used to gather data from the processes which is then transferred to the platform, which is the software part, for analysing. The platform has a user interface where end-user operators can see the information gathered form the hardware sensors, but the platform can also be connected in the customer's control systems so that Company B's software can control the processes automatically with the information it gathers with the sensors. With this the service customer can achieve cost cuts through process optimization.

Company C

Company C sells continuous condition monitoring for a wide use in factories. The end user can be any company that has rotating equipment in their factory. The chief operating officer was interviewed from this company.

Most of the companies that buy services from Company C, are industrial maintenance providers, but on a few occasions the service has also been sold directly to the end user. So, in most cases company C sells its services to a maintenance provider which then adds this service to their own service portfolio and can sell it further to their customers as their own service product. This way company C does not have to contact tens of factories to sell its services, the maintenance providers do that for them with their existing connections to possible end users.

The service offering consists of hardware and software. Usually, a handful of hardware sensors are attached to a single terminal by wire. These terminals are then connected wirelessly to the platform, which operates in cloud, for data storage, visualisation, and analysis. A total of four unique hardware items exists and they are designed to monitor different types of rotary equipment. This way the condition monitoring can be carried out in different parts of the end user's process.

Company D

Company D offers IoT tracking service for a wide use on different sectors. The hardware devices can monitor, for example, positioning, movement, and the surrounding environment. This information can be used, among other things, to locate a machine or to define one's utilization rate. The head of business development was interviewed to gain knowledge of company's offerings and operations.

The service works with IoT tracking devices that are small and affordable. They can be attached to nearly anything from humans to shipping containers to gather data where the carrier is and has been, or how much and how often it has been moving. This data is then stored in cloud servers, or temporary data buffers if connection to cloud is not available at a specific time. This data can then later be accessed easily with a mobile phone via Bluetooth. The data can also be stored for months before acquiring it from the cloud, this can be useful for longer time for analysis or for longer shipments.

3.2 Current state analysis

In this subchapter the current state of each case company, their operations, and service offerings are presented. The information was gathered from the interviews carried out with the case companies' employees. The interviews were carried out with a time limit and no further questions or explanations were presented afterwards, so this subchapter is based on the understanding the interviewer gained from the initial interviews. Each case company is addressed separately, and a combining current state synthesis is presented at the end of this chapter.

3.2.1 Company A

Company A's service offering helps metallurgical manufacturers in quality and process monitoring with devices attached with sensors and the platform that handles the gathered data. Most of the cash flow comes from direct device selling but in this thesis the focus is on the service offering, which is offered with these same devices. Sensors are attached to customer's manufacturing equipment to gather data from the process. This data is then transferred to the platform, which is the software, to analyse, store, and visualise the data in an easy-to-understand format which can then be used by the customer organization's operators and the management to monitor the processes.

Productization

There has been discussion within the company about the model the services are to be sold. In some cases, customers want to buy the devices into their own balance sheet from company A after they have found the service useful through device rental, thus getting rid of the service payments. When this happens, company A will charge a licence fee to cover the upkeeping of the platform and to maintain profitability. At least for now, company A has agreed to sell their devices and simultaneously has lost the cash flow from the device rental service agreements. The question if this is appropriate from company A's perspective have been thought. But since being a small SME company and dealing with large customer companies, company A just needs to try to please the customers and get revenue where it is possible.

Company A's service offering is quite unique. There is of course competition within the quality and process monitoring services, but specifically in the part of the metallurgical manufacturing processes where company A's devices operate and gather data, there are not many contenders. What makes this service unique even within this group of competitors, is the flexibility of the solutions that can be offered. The devices can be attached in different places depending on the machinery the customer uses; therefore, no big structures or changes in customers' equipment are needed for the installation. This makes it easier to implement by the customer, but it will also add work to the service provider, in this case, company A. Since every customer's equipment differs from each other, the service provider needs to make the needed adjustments to its own devices and service offerings for every individual customer which requires time and money. The need for constant customisation between customers has been recognised as a challenge for the company.

With no clear modular service structure, the services offered are always customised regarding single customer's needs. Defining the technical and the commercial items of the service offerings – creating productized services – and developing a modular service structure through that are recognised as a potential solution and some steps have been taken to reach that. One obstacle to reach the modular structure of services is to understand the value produced to the customers. The company does not have full understanding on how much value certain measurements and analyses bring to the customers, which makes the pricing and selling more challenging.

The constant customisation needed between solutions offered leads to variability also in the production processes of these services, which complicates the efficiency of the production. No process visualisation like flowcharts or service blueprints exist on paper or as a file in the company, instead the knowledge and knowhow of how things have been done and what has been working is in the employees' heads. This is also recognised as a weakness since everyone can understand a specific subject a bit differently and it can change even more when explained further to new people. It is recognised that a standardized model would be easier to execute and deliver to customers and again, some steps have been taken to reach that, but there is still work to do. The goal would be a repeatable system to produce the services.

The implementation phase is recognised as the most inefficient part of the service offering. It requires a lot of human working hours in communication with customers, planning the installation, and adjusting the platform according to customer needs. The hardware customisation is not seen as time consuming compared to the software which needs some level of customisation with every customer. A modular platform structure could be seen helpful.

The platform itself is not considered as an independent sales item when selling a service agreement. Instead, it is seen as a side offer that comes always with the monitoring services that are offered with the monitoring devices. There are only three different monitoring devices used to offer the services, but with customisation these devices have been capable of providing dozens of different solutions to customers. At least for now, it has been seen simpler to keep the number of sellable devices at three rather than productising all the different solutions developed from them. There have still been efforts to reach a modular structure with at least one of the devices to be able to minimize the redesigning, redoing, and distinct solutions.

Where the company focuses their sales and marketing will also affect their operations and offerings. It can be seen as a choice between two options: to sell a smaller number of different solutions to a larger number of customers or to increase the number of different solutions to enable increasing sales with a smaller number of customers. Company A has chosen the latter one because new customer acquisition is seen as a time consuming and long-lasting process, also a large selection of offerings can attract a wider customer base, which can be useful especially in the future. In big companies the investment decisions are not fast, and for company A, piloting the offering is not highly profitable, so it is easier to sell new solutions to the same companies and even to the same people that already understand the value of the monitoring service. Because of this a high employee turnover rate in customer companies has been seen as a negative factor. If the employee who has been the contact person and a kind of idea seller to the customer organisation's management leaves the organisation, company A needs to start building new relationships with the same company. This again takes time and effort.

Scalability

The role of the customer in the service offering is determined mostly by the service agreement. Company A is flexible in adapting to customers' wishes. In most cases the implementation happens in co-operation between the customer and the company: customer plans and explains what they want on the technical scope and the company then designs a working solution according to that. The possible platform integration into customer's own systems is somewhat simple and is done in co-operation. When the process and quality monitoring is working, the role of the customer is usually minimal but again dependable on the service agreement. The sold offering can be a turnkey service where company A takes care of everything from the platform to all the devices on site, but if the customer wants, company A can train customer's own personnel to do the basic maintenance needed for the devices. The platform is still always on company A's responsibility.

There were some differences in opinions within the company on which level of customer involvement would be optimal. Turnkey services provide more cash flow, and if the customers are located relatively close to company A's location it is possible to do the required maintenance work with a daytrip. If the customer is located further, partners are usually used for this kind of maintenance work. On the other hand, the question was raised on if it is efficient to travel hours to visit the customer's factory to do a fairly simple maintenance work that could be taught to customer's own maintenance personnel, thus saving time but also cutting sales from the company A's perspective.

IoT platform

The platform is operated in cloud, which is acquired from a third party, or on the customer's own servers if they prefer so. If the server space is acquired by company A, it is billed from the customer according to the needed and used amount of server space i.e., how much it will cost to company A. The platform is browser-based, and it is also compatible with customers' own platforms or systems with its flexible interfaces. This configuration is of course unique with every customer's system, so it will take time, but the configuration is possible and have already been used. After the configuration, the data gathered with the monitoring devices can be accessed via company A's platform's own user interface or by using the customer's own system where the same data is automatically transferred to. The data is handled and limited on the device level to limit the amount of data that needs to be transferred to the platform and stored in the cloud. This is mandatory for the system to be able to operate properly. Different customer's platforms are similar compared to each other's, but they are still individualised as own actors in the cloud. This is partly due to data privacy and partly due to the reliability protection.

Some collaborations have been made and more have been discussed with other companies that offer process monitoring services or equipment. In these collaborations the partner company's devices have been or would be connected to company A's platform and they would act as sensors just like company A's own devices. In these cases, the responsibility of the upkeeping of the partner's devices can stay with the partner or it can be transferred to company A, which could then act as the lonely service provider, but this is again an agreement matter. The main benefit for the partner would be the existing customer contacts company A has and over which they could then sell partner's products as well. Company A can then charge a fee for using its platform and possibly also for the sales channel the partner benefits of.

Upkeeping

The platform itself monitors the monitoring devices and the data they produce; if any abnormality is detected regarding the functioning of the devices, the platform will send error information to company A whose personnel can then take proper actions to fix it. But if some errors occur, customers' operators will also detect them fast and contact the provider. So, it is a two-part alarming system.

No continuous feedback gathering have been implemented between customers and company A, but it has been discussed. The platform could be used as the medium between the customer and the provider for feedback and, for example spare part ordering. The quality control over own operations is also seen insufficient. No quality inspections are implemented for own operations, however the offered devices and the platform are always checked before the installations.

3.2.2 Company B

Company B offers their customers a control and optimization system for a certain part of metallurgical manufacturing process with its unique measuring technique. The devices used to produce this control and optimization service are also sold directly without a service contract, but the focus in this thesis is again only on the service offerings.

Productization

The basic service offering consists of hardware components: three sensors, which are attached to customers equipment to gather the needed data from the process, and an equipment cabinet for the data handling. The software part consists of the user interface and the platform itself which analyses the gathered data, and which can be customised to control the customer's production processes. In addition, company B will provide installation, usually through their local agents, as well as the maintenance needed for their equipment. In the implementation phase the customer will be responsible for the usage of the signals given by company B's platform, but company B will execute the needed configuration between their own platform and customer's control systems. After the installation is ready company B will still help with the deployment phase to get the system to work properly. When this entity is sold as a service, the hardware remains as company B's property but are of course located in the customer's manufacturing plant.

Before the implementation takes place, company B needs to survey the target equipment to gain an understanding of what is needed to offer a process controlling service. Usually, company B has a good understanding of the customer requirements and wishes, but this conversation and designing phase can still take a couple of months before the implementation is started.

The service is at least for the most part, quite similar between different customers. The same sensors can be used with small customisation, and the equipment cabinets are standardized as two different versions. So, the same hardware can be used painlessly between different customers. The platform needs some level of customisation but there are modules regarding for example the level of controlling the platform can execute. The customer can then choose the level it prefers, and the price is determined according to that. There are also other possibilities to customize the platform but usually customers are satisfied with the offered software and user interface. The main differences between different customers are the maintenance service level and the level of automation integration, meaning the level of integration into the production systems.

During the last year, efforts have been put into increasing the efficiency of the production processes within the company. Documentation have been made for the production, assembly, and installation processes, even though the installation differs between different customers. Also, time has been spent in documentation of the devices and their possible customisations. The documentation also includes information for customers from the service offerings and their benefits for the customer. In addition, documentations have been made regarding the implementation phase: how it is carried out, what information needs to be given from the customer to the provider and vice versa. The deployment phase will be the next target of the documentation project. There are intentions to develop a framework for the platform deployment that would simplify the deployment phase. Even though the customer systems' configuration needs are different, there are still a lot of similarities where the framework could be useful.

The customer acquisition can be seen as the bottleneck at the current time, and since the additional sales to existing customers is quite a small business at this stage, the new customer acquisition is important. When the customer is ready to buy the service, the biggest resource needed to accomplish a new service are human working hours. While this is recognised, no real resource allocation between different processes has been carried out apparently. The devices themselves are rather affordable, and the platform is ready to be customised and configured for the customer's needs. The human working hours are needed in the assembly of the hardware, designing the implementation both for the hardware and the software side, executing the implementation itself, and the deployment phase. Regarding this production and implementation of a new service offering, the bottleneck is in the implementation and deployment phase that happens on-site at the customer's factory. This needs some special skills by the executors to be able to implement the solution, teach the customer's personnel and to monitor and help with the deployment. In addition, these employees need to be ready to travel to make these implementations.

One possible solution to tackle this installation and implementation challenge would be to outsource the implementation to a partner. Of course, proper instructions would be given by company B and they could be available remotely via internet to help and oversee the project. But it has been noticed that customers prefer face to face on-site service rather than remote guidance. This procedure is still being tested now as a concept.

Scalability

It has been recognised in the company that involving customers in the service production will increase the scaling potential of the company's business. But there is a conflict of interests with the current pricing and current number of customers, since the company is happy to provide for example the maintenance work for the customers instead of pushing the responsibility towards the customer. The devices are although build in a way that enables easy maintenance work and installations, so that customer's personnel could be able to install and maintain the equipment without any large-scale education.

Possible co-operation has been discussed with certain other companies to be able to provide a wider service for the process controlling purposes. The big question is about the roles of the co-operating companies. If one provided only hardware that was then connected to other company's platform, the co-operation would be quite straightforward. Otherwise, if both parties provided their own hardware and software, the service offering should be organised as equal partners. Company B would be ready for a wide range of solutions but of course it must be profitable for them.

IoT platform

Company B's platform operates in a server space provided by the company itself. It acts as a database for the data gathered from the customers' manufacturing processes. In many cases customers want to keep the data at a local level due to the data privacy policies inside the customer company, so in these cases the data base is located inside the factory plant and the server provider is then agreed case by case.

There are ambitions of a platform that could take information also from other monitoring devices from other companies to make the process controlling service broader. But this is not yet possible. The connection to the customers' systems is however very usable and a key part of the whole service offered. The platform is configurated into the customer's control systems so that it can automatise the controlling as much as the customer wants. The automation customisation can sometimes be a bit tricky and time consuming at this point.

Upkeeping

The small and rare maintenance work needed for the devices are now taken care of mostly by company B. Although, there has been discussion on the maintenance operations and which party should take care of them. The maintenance services are provided without any real profit intensions, so the invoiced amount just covers the expenses of the needed work. There are still a few customers that have decided to do the maintenance work by themselves, but they are rare. In these cases, company B provides the needed spare parts and other support when needed. The operations are heading in a way where the maintenance work would be made either by the customer itself or a third party, and this way the workload could be reduced from company B.

The data gathered from the customer's process is overseen in two ways. Company B demands a remote access to the systems so that it can monitor its devices and detect possible defects in the controlling process, but also the customer will of course oversee its own processes and contact company B if problems occur. Some investments have been made for an automatic diagnostic system that would monitor equipment and the platform's data automatically. At this stage, the monitoring is executed manually remotely by company B's own personnel in certain predetermined intervals.

3.2.3 Company C

Company C provides data and analysis services with their hardware and software that can be used for continuous condition monitoring in different kinds of manufacturing and production processes. Direct sales to end-users are only a small portion of the sales, since most of the services are sold through company C's partner network. In these service agreements, company C provides the tools for condition monitoring to its partners whose business is to provide condition and process monitoring services for their industrial customers. The sold system consists of several hardware sensors that are connected through wire to a terminal that is then connected wirelessly further to a cloud server where the data is stored and analysed. Also, a user interface is provided to view and use the data onsite.

Productization

The devices used for the monitoring are sold as products with a single acquisition price with no weekly or monthly expenses for the customer. At the current time, the device sales are a big part of the cash flow, since their prices can match even several years' payments of the platform which is sold as a service with monthly fees. In the future the business model will still rely on the monthly payments because that is the more scalable cash flow.

The offered monitoring concepts contain the hardware devices and the platform. No devices are sold without the platform but in some cases only the platform have been sold, in these cases the data is then gathered with other manufacturers' sensors and only stored and analysed with company C's platform. The provided concepts are designed for different end-user equipment and are standardized to a certain level including the devices (sensors, terminal, and cables), the measurements they provide, and the platform's user interface the partner and the end-user can see and use. This concept can then be customised further regarding, for example, the data replication and additional measurements taken, which will then affect the pricing. The platform itself does not need much customisation between different end-users, making it highly scalable system. The biggest variable regarding a new end-user is the implementation phase and its configurations, but this work is done mostly between the partner and the end-user.

The service offerings are built from four different devices that have modularity between each other, and from the platform that needs very little customisation between different end-users. This enables very similar processes between various service deliveries. The goal is that partners can offer their service individually without company C's help while company C ensures that their service is working well meaning that the devices and the platform works.

The processes for a new end-user or new installed equipment are small from the side of company C. Company C will provide a ready-to-use evaluation kit for their partner that can be used when they implement company C’s equipment with a new customer. The implementation itself happens solely by the partner. There is no actual design work or such that would need to be done by company C, they just provide the platform and the needed devices, and the partner does the implementation. An exception to this is when the partner is new, and training needs to be given that way. If the service runs well, company C does not need to do anything else than make sure the platform is working properly thus making sure the service is fine from their part.

The resources needed to provide the service offerings are known to a certain level. The number of resources needed for the platform are not big because it can be scaled well. A new customer or new devices will not instantly trigger a need for new server space or such. Most of the resources needed for new service offerings are human resources. The need to customise the offerings between different customers, although being small adjustments, will still take human hours to be done. The most time-consuming processes are the first implementations made with a new partner since their personnel need to be trained to implement, start up, and use the gathered data. This will usually take around five implementations every time needing less and less participation from company C’s personnel. This phase can be seen as the resource spender of all the executed operations.

Scalability

As discussed, the main customer base for company C are the partners that offer maintenance and condition monitoring services for their industrial customers. These partners have their own service agreements ready with their customers, and this way company C does not have to market its products directly to the end users. The aim is to grow along the partner network. When a partner makes a new service agreement with its new customer, they will offer services that are provided through company C’s equipment, which will increase sales for both companies and enable better condition monitoring for the end user as well. So, the focus in growing the business is not to find a lot of new partners or end-users but rather grow as the partnering companies grow. In the rare cases of direct end-user service offerings there are also possibilities for additional sales within the same company. These direct end-user customers have been accepted as direct customers because of this possibility.

Customer and partner involvement are on a very high level in company C’s operations. After the first few installations and start-ups, or when the customer personnel can manage the operations by themselves, company C will not get involved in the implementations nor the everyday usage of the service. Even the configuration needed for the software needs to be carried out either by the partner or by the direct end user customer, company C will provide the needed training for this as well.

From company C's point of view the most time-consuming tasks are the first deliveries made with a new partner, where company C needs to be present and guiding the processes. This needed time is divided between the installation part and the configuration part. The system configuration to get the devices working and gathering correct data can be done remotely, but for the device installation company C personnel is needed onsite. Both take a few hours to execute.

IoT platform

Company C uses serverless architecture in their platform. This means that new space for data is acquired when and only when it is needed. This is acquired from a third party and it works in cloud. This means that when the number of end-users and attached devices increases, the price for the cloud space will increase along, but this cost can then be transferred to customers. This way company C cannot end up in a situation where they run out of data space. The gathered data is also limited and assembled on the device level to be able to minimize the data space needed for transferring and analysing. The devices gather huge amounts of data and this data is then sorted and packed before transferring further.

The platform can use information also from other manufacturers' devices along with company C's own sensors. One co-operation has already been carried out with a third-party device provider. At the current time the devices from this provider need to be transported first to company C where small adjustments are made and then to the customer. But the goal is to get rid of the intermediate position, so that the devices could be shipped straight to the customers or partners who will install them. The only limiting factor for additional devices is that these monitoring devices needs to send acceptable data that the platform can read, otherwise the infrastructure is ready. The platform can also be connected to other systems like maintenance organisations' own systems or end-user's enterprise resource planning systems. This action is referred as data replication, as the data that could be shown in company C's browser-based user interface is replicated into customer's own systems so that it can be viewed via it as well.

Different users' platforms are stacked vertically and using the same resources to work with. The platform is redundant in the cloud, meaning that it is not dependent on a single data centre, making it not so vulnerable to system errors. Also, the platform is working in such form that a single user cannot make errors that could cause harm to other users, making it safer to operate on.

Upkeeping

The needed upkeeping work is made by the partners who sell the services to the end-users. Of course, company C needs to make sure that their equipment can provide real time data and analyse it properly, which is ensured with updates. In the case of direct end-user sales, the responsibilities are agreed case by case. However, there is no prescheduled maintenance plan for the devices, they should be able to run their lifetime, which is 20 years, with no actual maintenance work.

Upkeeping work is made easier with log data gathered from the devices. In cases of any kind of errors the log will issue an automatic signal that will report the error to the system user. In most of the cases the needed repair can be carried out remotely, even to individual devices through the platform.

The quality of own service offerings is observed with the error messages from the devices and with other information gained from the customers. If some types of errors repeat themselves, it will often trigger improvements for the devices that will then be carried out. Ideas for new monitoring devices or improvements for current devices can be received from customers as well. If these ideas are found good and useful, they can be used with other customers as well. Ideas for new types of monitoring can be received from customers and if good these ideas could then be used also with other customers as well. Regular meetings are also arranged with partners where needed developments and possible future devices are discussed.

3.2.4 Company D

Company D offers locating and circumstance monitoring services using IoT technology. These systems can be used in factories, constructions sites, and for example shipment monitoring to monitor vehicles' positions and utilization rate, or for example humidity changes in a storage building.

Productization

The service sold to different customers is roughly the same. It uses Bluetooth tags that can be attached to nearly anything, these tags have company D's software inside and one or more individual sensors to measure a certain parameter. The data gathered with these Bluetooth tags is then passed to the cloud servers where it can be easily accessed by for example a mobile app. Although, every service has a lot of similarities like described, each solution is still a result of customisation regarding the customer needs. A same type of tag device with several sensors can be used somewhere to measure humidity over a long period of time and elsewhere the utilization rate for a truck, this makes the service providing easier for different uses. The customisation needed between customers can often be done fully on the software level by changing the measurements shown and their definitions on the platform that the customer uses. One special thing about company D's operation is that they have no hardware development themselves, so the hardware needs to be available on the public markets. Own software is installed afterwards to the acquired hardware, so that the devices can communicate with company D's own platform.

In many cases the customisation made for individual customer aims to improve the service offerings for the future. One customer that contacts company D and wants a certain type of tracking service is most likely not the only one who would benefit from such type of service. This way the service portfolio can be expanded. This is done mainly by adding a new element to an existing offering.

Since the hardware production and development are outsourced, coding is by far the process that needs the most resources when designing and implementing a new solution for a new customer. This also means that most of the employees are coders. Besides the coding, also other processes that are needed for service production are identified and defined at least on some level.

Scalability

Company D's sales are divided between new customer sales and additional sales for existing customers quite evenly, the additional sales being maybe slightly more significant. This is mostly due to the hesitation with the first service offerings bought. When the benefits are noticed within the customer company the additional orders are way larger than the initial test order.

With the first implementations, company D will take the responsibility of installations, designing, and start-ups, but during the first installations customer's personnel will learn the processes so company D can loosen its participation. So, when the service is up and running the operating is in customer's hands. This switch of responsibility is also in the customer's interest because the full service would cost them a lot. With many smaller end-user organisations, the sales are carried out through a third party, which sells company D's services as their own. In these cases, the first implementations are again carried out by company D but after that the third party takes the responsibility of the operations needed to take care of the equipment, while company D provides the needed additional equipment and takes care of the platform.

One aspect that slows down the growth and scalability is the slowness of the customers. After the first service package is delivered and put into action it will take several months before the customer is ready to invest more in the service. With the first service package the incoming cash flow is relatively small, so it would be important to get additional sales as quickly as possible. One way to tackle this problem is to sell the services in several smaller organisations within the same company, thus speeding up the sales process.

IoT platform

The platform operates in cloud which is acquired from a third party. These expenses are not billed directly from the customer, but it is included in the service payment which is device based. Since the billing is made based on the device count there is apparently no difference for the customer how much data it gathers with the devices because this will not affect the pricing although it can affect the costs for company D with the cloud space payments. The amount of data that is gathered by the sensor tags have not been seen as too large of an amount to handle, so it is limited on the device level only in specific cases before it is transferred to the cloud.

A mobile app acts as the user interface for the platform. It makes the operating easy, since only the app is needed to get access to the gathered data. The platform can acquire information from new third party devices since that is the business idea, no internal hardware designing takes place. The platform can also be connected to customer's own systems to transfer data easily from system to system. Company D provides its own user interface that the customers can use, but it also offers the integration into customer's systems, if that is what the customer wants. These integrations are time consuming for company D and expensive for the customers, but usually at the point when the customer decides to invest in, for example, thousands of sensor tags, they want the integration as well to get the best value from the service.

The customers are organized horizontally on their own platforms. The communication system for every customer is the same, but they are separated into individual systems due to data privacy policies. This structure makes sure that wrong equipment cannot communicate with each other's.

Upkeeping

The used sensor tags are very affordable, the basic one's costing under twenty euros per tag. They are also reliable, only a few have broken down and those are mainly caused by faulty attachment or similar user errors. Since the tags are so affordable no big efforts are invested in repairing the broken ones which are then just changed to new ones. No actual scheduled maintenance takes place due to the cheap and reliable tags.

The data that is pulled out of the devices is overseed by company D's personnel. Predetermined processes are used to monitor the data quality from the devices and artificial intelligence is used in the platform itself which makes the monitoring more automatic. In case of any errors, the system will issue error or warning signals through different media depending on the urgency of the problem. This is essential because the service is running round the clock.

There is no organised feedback or development conversation arrangements between company D and its customers when the service is up and running. But during the first implementations, even weekly discussion sessions are held so that the service can get started smoothly. The implementations will almost always contain some level of coding or system integration in addition to the tag and platform deployment, so these frequent discussion sessions are essential for the implementation to succeed.

3.3 Challenges in service scalability

One key challenge that came up with the case companies' current states was the lack of documentation and standardization of the service offerings, and the processes needed to produce them. Some level of process documentation existed in two case companies and at least one had intentions to standardize and document the production in the future. No company had fully documented processes for the service production and for the service implementation, and start-up phases that could be used with every customer.

The service offering side was not well defined and documented within the case companies either. No service portfolio structures existed among the companies, where the offerings could be visualised for the companies themselves and for the customers as well. In addition, only one company stated that clear modules exist between its hardware items, which makes the production process easier and more scalable, of course since one company outsources its hardware this does not concern it.

The service portfolio structure theme had been thought by one company and some documentations already existed that could be used as a part of the visualisation. This same company had also recognised that a modular structure in the platform could make the service providing easier and more efficient between different customers, but at the same time the platform was not addressed as a sales item by its own, rather it was a part of every service offering as a side-product for the monitoring devices. Also, the company had challenges understanding the value its service offerings bring to the customers.

Resource allocation was another theme that was not defined well at the case companies, which is at least partly due to the lack of process and service offering documentation. Every company had identified human resources to be the main resource needed for service production and offering. But it still appeared that the needed human working hours for certain tasks were not know precisely in any of the companies. No documentation existed that would present the resources needed to provide a specific type of a service to a customer.

The customisation and flexibility between customers are a part of the high value service offering that will attract customers and enable higher pricing with unique and well-fitted solutions. The constant customisation between customers, even if quite small in some cases, disturbs the productization, modularisation, and scalability. One company had made a deliberate decision that it would rather widen its product portfolio to be able to sell more to its existing customers than focus only on potential new customers with its existing service portfolio.

Stakeholder involvement was another element that could be improved in the case companies, more in some companies than others. It is understandable that the implementation and start-up phases require service provider's involvement but as one company mentioned this could possibly be carried out remotely in the future, and they had a pilot implementation coming to test this. It was although mentioned that at least for now, customers would prefer onsite face-to-face service rather than remote education and guidance through internet.

Two companies had recognised that basic maintenance work and similar will take time and require working hours but on the other hand, they were not rushing to get rid of that business. The upkeeping work bring cash flow and with the current state of operations, this is seen as a viable business.

3.4 Current state analysis synthesis

This chapter presents the synthesised findings from the interviews conducted for this thesis and the challenges found in them. The views of the case companies' current states were presented individually for each company and after that a summary of the challenges were presented. This subchapter draws together the key factors from the case companies, their service offerings, and processes, and tries to answer the second research question: "what is the current state of the elements that would enable service scalability in the case companies?".

There are a lot of similarities in the offered services between the four case companies. The main value adder in all the service offerings is the platform that does the work to get understandable and useful data from the monitoring devices. Two of the companies can use their own monitoring devices and devices from other manufactures, one company uses only its own devices, while one uses only devices from other manufacturers. But with every company the data is then transferred into the platform where it can be viewed through company's own user interface. Each of these platforms are also integrable into customers' own systems allowing data replication and in one case also process controlling.

The literature review presented in chapter two, resulted in seven key elements from three different categories that affect the scalability of services offered through an IoT platform.

According to the literature, these seven factors should be dealt with to be able to offer highly scalable service offerings. Table 2 presents the current state of the case companies' operations regarding these factors.

The element "getting rid of capacity constraints", which includes all the resources needed like money, work, server space, etc., was not achieved by any of the companies. This is easily the hardest element to overcome, and it would need fully automated systems with zero manual work needed for a new service agreement. This element can be seen impossible to achieve with companies this new, small, and with still evolving service offering selection. Tackling the other challenges will although help the case companies to get better regarding this element as well.

Table 2. The case companies' current state of scalability.

	Company	A	B	C	D
Creating value to customers	**High value and unique service offering**	Achieved	Achieved	Achieved	Achieved
	Productized service with a modular structure	Understood the possible value, little action	Some level of productization and more is planned	Some level of productization and modular structures	No HW production, a lot of individual SW customisation
Taking advantage of the platform	**Getting rid of capacity constraints**	Not achieved	Not achieved	Not achieved	Not achieved
	Involving stakeholders	Recognised the benefits, aiming towards it	Recognised the benefits, but e.g., cash flow from upkeeping work is valuable	Own involvement needed mainly only in the first deployments	Own involvement needed mainly only in the first deployments
	Selling data instead of working hours	Achieved	Achieved	Achieved	Achieved
Taking future needs into consideration	**Connectivity**	Can be connected to other platforms & systems and host other devices	Can be connect to other platforms & systems, but not yet devices	Can be connected to other platforms & systems and host other devices	Can be connected to other platforms & systems and host other devices
	Flexibility	Achieved	Achieved	Achieved	Achieved

4 IMPROVING SERVICE SCALABILITY

In this chapter a solution is presented which would hopefully improve the scalability of the case companies’ businesses. The solution is presented by mirroring the best practises found in the literature review against the challenges found in case companies' current state analysis. The aim is to define an answer to the third research question: “How can the case companies scale their IoT platform-based service offerings?”.

Based on the case companies’ current challenges a service productization model can be seen useful for all the case companies. Productization is the action of modelling the service offering to consist of certain modularity and enable commercial configurability to meet the customers’ needs. (Ruohonen et al., 2006) The case companies should take this step in the near future to be able to scale the business and keep prices down.

Harkonen et al. (2015) found eight characteristics of productization of services, all of these characteristics match the case companies’ service offerings and operations. The eight characteristics are as follows:

- “A process/development phase
- Standardisation/systematisation/better definition/reproducibility
- Making tangible
- Making something marketable/saleable/ready commercially
- Value creation
- Improving customer understanding/demonstrating value
- Packing to a form suitable for customers
- Defining offering based on needs”.

The offerings and the processes should be developed towards a more standardized model that would be easy to understand like a tangible product. A more defined and understandable offering is easier to sell and market because customers understand better what kind of extra value they are getting with the service. The only challenge is with the understanding of the value a certain service provides to customers, which was a problem for at least one case company. If this can be clarified the productization can be made in the most suitable form from the customer perspective and create the value in the most efficient way.

Modularisation is another key element that should be included in the processes, monitoring devices, and service offerings to be able to act more efficiently in the future, and thus enabling better possibilities for scalability. A modular structure is one key part of service productization while it makes it easier to manage and price the offerings, and the whole communicating with customers becomes easier. The three service modularity segments – service modularity, process modularity, and organisational modularity – should be modular entities for the whole service structure to be modular. This means that it is not enough that single service offerings share common modular pieces, but the modularity should start from the organisational level, go through processes and end in modular service offerings.

This productized and modular service portfolio could then be linked to the resources that are needed to execute the processes to provide the case companies' services. By linking the resources to the service offerings through resource drivers the case companies can get an understanding of the resource needs for certain sales items that are part of the provided service offerings. This knowledge can for example draw interest towards the possible stakeholder involvement, since the resource drivers reveal the human and other resources needed for basic upkeeping of the devices onsite in customer factories.

When the service is fully operational and only rare maintenance work is needed, it should really be considered if the service provider wants to make these maintenance tasks by itself or execute them through, for example, agents that are on the provider's payroll. The needed basic tasks were described as simple upkeeping work that would not require any intense and long-term training or specialisation for these devices. The platforms and the software side of the monitoring devices could however be kept under service providers' responsibility, since the upkeeping could be managed remotely with small updates.

The direction in which the additional sales are pursued should also be taken into consideration. Due to the challenges and slowness in new customer acquisition, one company had decided that it would rather widen its product portfolio further to be able to sell more to its existing customers than focus only on potential new customers with its existing service portfolio. This might end up increasing the sales faster in a short run, but it is not necessarily the right way to build a truly scalable service business. A suitable middle ground should be found in which the service offerings could be modular, and the service structure could be productized, but that would also enable the needed customisation between different customers.

The following subchapters will present two different productized service portfolio models for two different service scenarios. The first one will have the monitoring devices sold as products and the platform is sold with a monthly fee, while the second scenario has monitoring devices sold as rental service items and the platform is charged depending on the usage.

4.1 Productization scenario 1: Platform as a monthly-based service and devices as physical products

The Figure 7. presents a productised service portfolio model for a monitoring service. Depending on the case company the product families can consist of different industries or different kind of monitoring service, like for example location or environment monitoring. Product configuration separates the platform from the devices. In a usual case customer will buy sales items from both configurations, but it is also possible to sell services only from the platform configuration. In these cases, the customer will acquire the monitoring devices elsewhere.

The sales items regarding the platform are *platform licence* and *platform customisation & configuration.* The platform licence provides the right to use the platform for data storing and process monitoring with the basic version of the platform. Platform customisation & configuration sales item is bought to get more out of the service offering by optimizing the platform for the customer company and possibly configurating the data into customers' own systems. This sales item is optional and if bought the process will be part of the platform process as demonstrated in the figure.

Under the sales items, the dashed line presents the line between commercial and technical portfolios. The first items on the technical side are the version items. This row represents the version of the sales item over it, the version can change for example when the sales item is upgraded. The different version items can be separated with a digit, like version 2 or version IV.

In this scenario the *monitoring devices* are sold as products into customer's balance sheet and because of this the technical structure of this sales item is demonstrated as a physical assembly. Optional sales items regarding the monitoring devices are *device installation & implementation* and *device upkeeping*. If the customer has got similar devices already in use and therefore knows the installation and implementation process, it can choose to do this step by its own. With a new customer this sales item is technically a must since the customer does not have the knowledge to execute the installation and implementation by its own. The device upkeeping can also be bought as a service which would free the customer completely from the upkeeping responsibility, but it will of course be invoiced accordingly.

The processes are then further linked to resources needed to produce them. In this scenario *working hours* are needed for the platform customisation & configuration since that process consists of communication with the customer and coding the platform. In platform upkeeping working hours are needed for maintenance work so that the platform will work properly during the whole service agreement period. *Cloud/server space* is needed for platform upkeeping according to the data usage by the customer.

For the device-based processes working hours are needed for both the installation & implementation and for the upkeeping processes. Installation & implementation needs to be made at the customers' plant, so requires working hours but also some travelling. The device upkeeping can at least partly be done remotely but, in some cases, it needs actions on the spot as well. *Tools* are needed in the installation phase for attaching the monitoring devices, while *spare parts* are needed for the upkeeping process to do maintenance work.

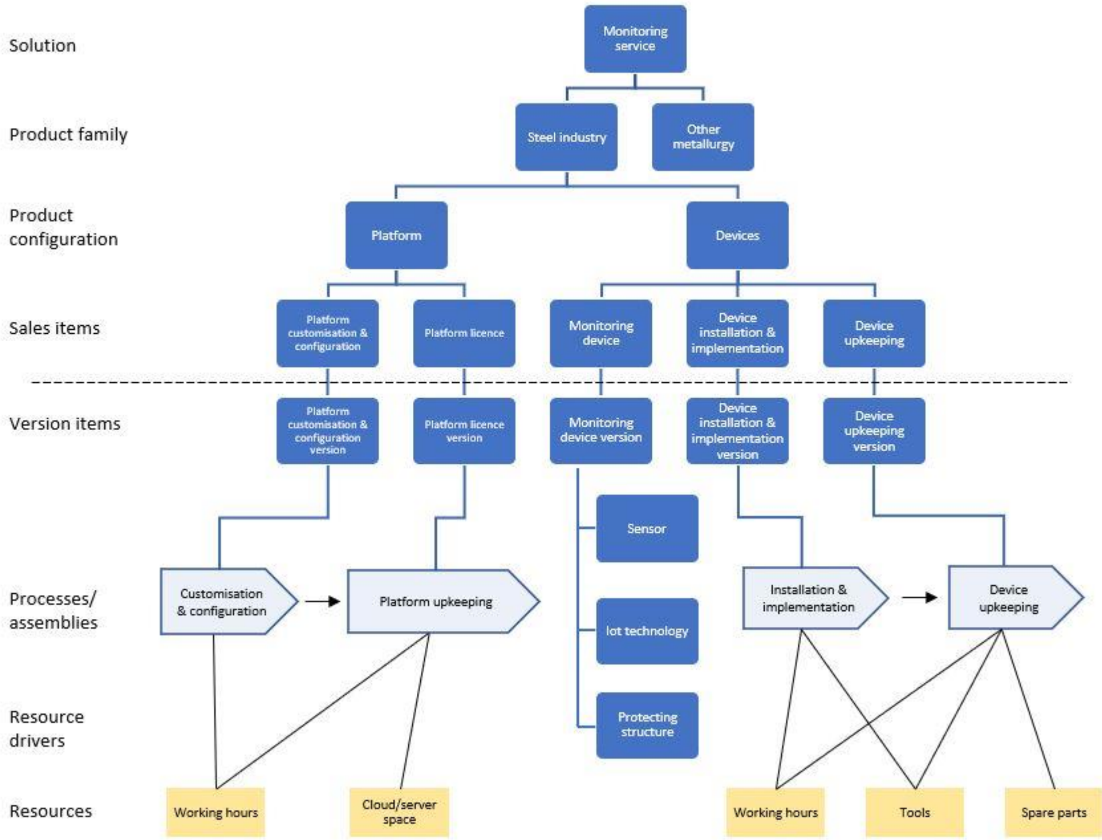

Figure 7. Productized service portfolio with monthly platform fee and monitoring devices sold as products.

4.2 Productization scenario 2: Platform as a use-based service and devices as services

Figure 8. presents another scenario for productized service offering. In this scenario the platform is sold with use-based invoicing rather than with a monthly fee. Because of this there are different *platform service* sales items which represent different amounts of data transferred and stored with the platform service. The more data is used the more the service will cost. The different sales items could represent certain amounts of data with a step-by-step style. When a certain amount of data storage in a certain time period is exceeded the customership will jump to the next platform service level with a higher fee.

The *platform customisation & configuration* is again as an own sales item that can be bought as a side product for the platform service. Because of this it is also visualized as an own process that precedes the platform upkeeping process. In this scenario the *devices* are sold as a *rental service* which includes the installation, implementation and device upkeeping services in this sales item and they are therefore not sold separately as own sales items. Version items are again presented under the equivalent sales item.

To offer these sales items certain processes are needed to produce them. The *platform customisation & configuration* is again a separate process since a service can be bought with or without the customisation & configuration sales item. The process for the platform upkeeping is named *1 year platform upkeeping*, this demonstrates that the service runs for a year and then the agreement needs to be renewed which has it own subprocess as seen in the figure. Customisation & configuration needs again *working hours* to be carried out. The 1-year platform upkeeping process needs some working hours to keep the platform up to date and *cloud/server space* according to the amount that the customer uses, which is of course dependable from the service package sales item the customer has chosen. In the end of the year the service agreement will be hopefully renewed which needs a small number of working hours as well.

In this scenario there is no assemblies presented for the devices since they are sold as a rental service rather than physical products. One sales item and therefore also one process describes the rental of one single monitoring device. The device rental service is carried out with a *1-year device rental* process, which includes *installation & implementation*, *service upkeeping*, and *service agreement renewal* subprocesses. The *monitoring device* will be located at the customer factory for the rental period and is therefore needed constantly for the whole rental period which is why the resource is linked directly to the 1-year rental process. Other resources are linked to the subprocesses inside the main rental process. For the installation & implementation *working hours* and *tools* are needed to carry out the subprocess at the customer's factory. The *service upkeeping* subprocess takes potentially *working hours*, *tools*, and *spare parts* to be fulfilled. This process might include some protective structure cleaning or renewal, device driver updating or other tasks that are needed to keep up the monitoring device. In the end of the year the service agreement is hopefully renewed in the *service agreement renewal* process, which takes working hours to be executed.

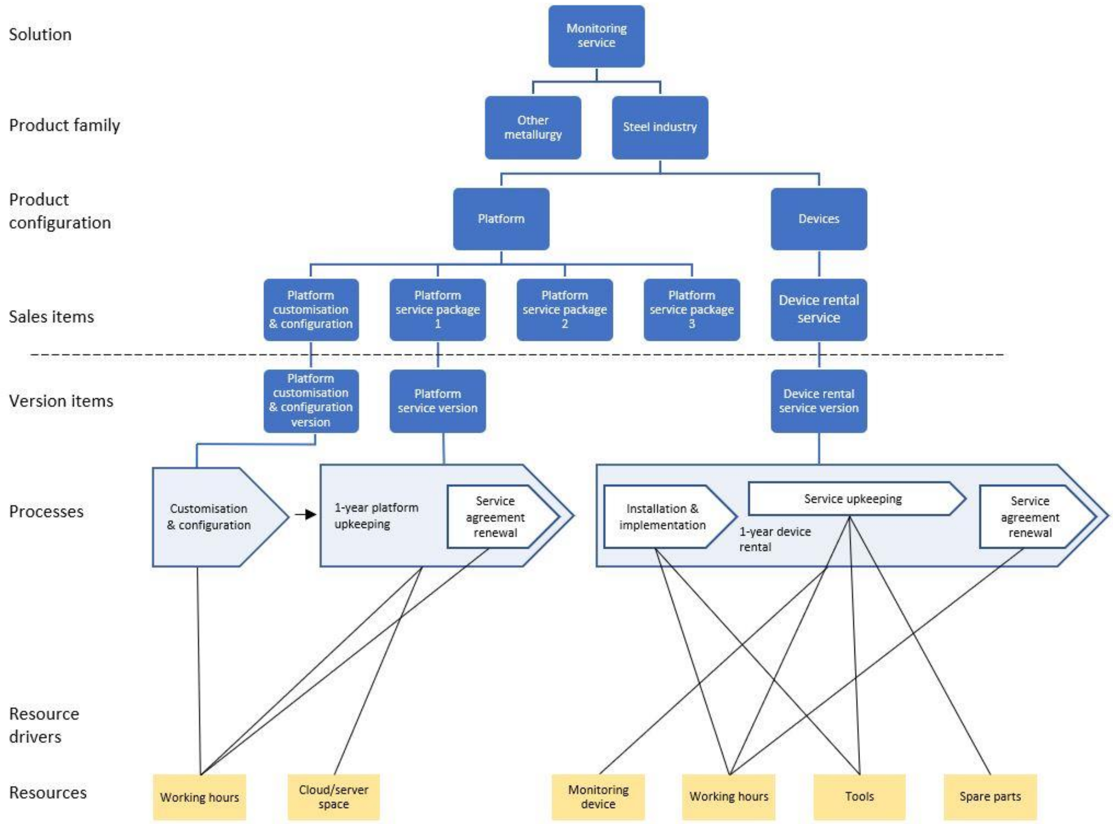

Figure 8. Productized service portfolio with use-based platform fee and monitoring devices rented as a service.

5 DISCUSSION

5.1 Main results

This study investigated service scalability in IoT platform context. The study aimed at finding the key elements that affect service scalability in IoT platform business and to identify the elements that were hindering the scalability of service offerings of four case companies. Further, the aim was to develop some proposals to improve the companies' service scalability.

The literature review provided a total of seven elements in three different categories that should be taken into consideration and overcome to be able to scale an IoT platform-based service. The first important challenge when designing a service is the value creation to customer, it is the basis of a good service offering. It would be even better if the value proposition was unique and hard to copy by other companies. The service offerings should be well documented and the processes to produce the services should be systematised and effective. A productized and modular service structure is a necessity. The platform itself can be used to decrease the need of human working hours from the provider company. This can be done by making the service offering such type that the value created for customers comes from offered data rather than from human interaction or human work. Also, involving stakeholders, like customers or partners, in the service process will diminish the human work needed from the provider's side thus, diminishing capacity constraints and making the business more scalable. The last important factor to take into consideration is the future. The platform and the whole business need to be able to evolve while the environment changes, thus making the platform flexible and enable good connectivity also in the future is important.

The current state analysis tried to define case companies' current operations based on the seven IoT platform scalability elements. The case companies had managed well the high value unique service offering, platform flexibility and connectivity, and selling data instead of human working hours elements. Getting completely rid of all capacity constraints at this point of the case companies' life cycle and with these kinds of service offerings can be seen impossible to overcome at this point, however the case companies can still get closer to that also in the near future. To achieve that, the case companies should tackle the other two elements that they were lacking in: stakeholder involvement and productized service offering with a modular structure. The stakeholder involvement was at some level in every company but could be improved especially in two companies. Productization and modularisation related documentation of the service offerings and the processes within the case companies was seen lacking as well.

Models for two different service portfolio productization scenarios were proposed as a solution to the case companies' service scalability related challenges. These models can act as a base logic for the case companies when they draft their own complete productized service portfolios. The models consisted of sales items that were linked to processes or assemblies regarding the nature of the sales item, and the processes were further linked to resources needed to produce them. This kind of documented map may help the case companies to better understand their own service offerings and the structure of these service offerings.

5.2 Scientific implications

Earlier studies have already combined the terms "scalability" and "IoT" since that is what IoT brings to businesses. IoT platform is less frequently mentioned with scalability in the context of scaling business rather than the scalability of the platform itself. Scalability of the platform is of course essential for business scalability, but the focus in this study lies on the business side, which can be seen as taking the scalability to the next level. A scalable platform-based business needs a scalable platform, but a scalable platform does not necessarily mean a scalable business. Lund & Nielsen (2018) discussed business scalability overall and found that a platform is one way to achieve a business with better scalability, since it helps with stakeholder involvement. This study analysed further the relationship between IoT platforms and scalability and found also other constraints of scalability, that can be tackled with a platform-based business.

Service productization has also been discussed in earlier studies, and the product portfolio structure with technical and commercial portfolios has been introduced by, for example, Mustonen et al., (2019). However, a productized service offered as a platform-based service with technical and commercial portfolios has only been discussed once (Lahtinen et al., 2019). This study brings productization with product portfolios into the context of IoT platforms, which has not been done earlier thus, widens the area where productized service offerings have been used. The resource drivers also bring a new element for the productized service offerings, since only cost drivers have been used earlier by Mustonen et al. (2019). Also, the firm focus on scalability aspects brings a new view on service product portfolio structures.

5.3 Managerial implications

As earlier literature states, enabling scalability is a key part of any growing business. Service scalability has always been seen harder than scaling production of tangible products, but recent studies have also tried to tackle the scaling constraints for businesses offering services. The literature review of this thesis provided the key factors that act as the constraints for businesses to scale their service offerings that are offered with an IoT platform based on the earlier literature. This list of elements found to benefit the scalability of service businesses can act as a checklist for other companies who operate with a platform-based service business and want to scale their business.

The empirical study provided examples of challenges regarding the scalability of service offerings in four case companies. The key finding was that the standardisation, systematisation, and modularity inside the operations and the service offerings were lacking. To tackle this, a productized service structure was proposed to improve the understanding of the processes inside the provider company and to improve the understanding of offerings for both the provider and for a potential customer. If the potential customer can easily understand what the service offering offers to it and of what kind of items the customer can choose the offering from, it should be a lot easier to buy the service. Additionally, when the provider has a complete understanding and documentation regarding its processes and offerings it is easier for it to function efficiently, flawlessly, and precisely.

5.4 Research evaluation and limitations of the study

Adams et al., (2014) presents three criteria based on which the quality of data can be evaluated. These are reliability, validity, and generalisability. Reliability means the consistency of the findings it does not matter if the findings are wrong as long as they are consistent. Validity tells if the measurements have been taken where they should have, while generalisability describes the level in which the presented solution can be used outside of the sector the study was made in.

This thesis was carried out as an empirical research with four case companies that offer IoT services through their own platforms. The small number of case companies and especially the small number of interviewees limits this study's reliability. This came clear when even between two interviewees from the same company there was quite a big difference in their views of the operations and how the business is working. Also, the challenges differed between these four case companies, so other companies can have completely other kinds of challenges regarding their scalability.

Validity of the research can be seen satisfactory since findings in the literature could be linked to the challenges in the case companies. A productized service portfolio with modular structures was seen useful for every case company and it was one of the seven elements that were presented in the literature review to strengthen the scalability of service providers who operate through an IoT platform. However, the presented productization models were not tested during this thesis so the solution cannot be validated at this point. This validation could be done with new interviews after the proposed model has been set in place.

The presented solution was moulded for the combination of challenges identified in the case companies and is not an ultimate answer to all scalability issues even for these specific companies let alone other companies. So, the generalisability of the presented solution can be seen quite weak. The presented solution is rather a guideline which way the operations should be shifted towards, and a suggestion of a model that could be used to benefit companies' understanding of their service products and processes. On the other hand, the findings presented in the literature review were a combination of information from several sources and were used in different kinds of environments. Those findings can be seen rather generalisable.

Taking the suggested improvement actions in the case companies was not within the scope of this thesis. This means that the recommended improvements have not yet been implemented in real life and their effectivity has not been verified in practice. On the other hand, the productized commercial and technical portfolio has been presented also in earlier studies, of course in a different form but it can be seen as a working model for visualising company's offerings and processes needed to produce them.

5.5 Future research

Since the recommendations of this study were not tested during this thesis, another study would be worthwhile to determine if the presented solution is the way to rework the service offerings in the case companies. This future study could focus on the effects of the actions taken after this study to determine if the proposed model is a decent way to tackle the scalability constraints of IoT platform-based service providers.

The solution presented in this study could also be modified and tested on other companies who are operating with same kinds of service offerings. This would either verify or question this thesis' conclusion. A few commercial and technical portfolio structures have been presented in the literature for both products and services but the actual benefits these models bring have not been investigated that much.

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APPENDIX

Appendix 1. Interview questionnaire

Basic information

- Name
- Company
- Role

Service productization and modularisation

- What kind of service is the company offering?
- How is the offering marketed?
- What kind of service entireties are the customers offered?
  - Are the services divided into assemblies which can then be combined into sellable service offerings?
  - Do the customers choose their service from pre-made packages or service items, or are the service offerings customised for single customers?
  - Are there remarkable differences in the service offerings between different customers?
  - What kind of differences are there? What parts of the service is configurable by the customer?
  - What kind of service components are sold the most, components that nearly every customer buys?
- How are the services produced?
  - Are the processes needed for the service production defined/systematised? (for example, Service blueprint)
  - How are the most sold services produced? What kind of processes does this production consist of?
  - Are the resources needed for different service offerings defined?
  - What resources are needed for each service process?
  - How much are each service process using these resources?
  - Can same equipment/processes be used to serve different customers?
  - Is anything new even needed, or can the service package be built from the existing resources by using existing processes?

Scalability

- Who are the customers?
- Can growth be created through existing customers buy selling more to them, or is it only possible through new customers?
- What is the role of the customers in the service providing?
  - Do they for example install, plan, design something or are they involved in the process in any other way?
  - Could some of the tasks needed for the service providing be transferred to the customer's responsibility?
- Which device providers are included in the platform economy?
- What is the role of these device providers in the service providing?
  - Do they for example install, plan, design something or are they involved in the process in any other way?
  - Could some of the tasks needed for the service providing be transferred to the device provider's responsibility?
- What kind or other partners are there in the service providing through platform economy? Who are they?
- What is the role of these partners in the service providing?
  - Do they for example install, plan, or design something or are they involved in the process in any other way?
  - Could some of the tasks needed for the service providing be transferred to the partners' responsibility?
- How easy is it to grow the service providing?
  - How much resources/working hours are needed for a new customer? In what are these resources used?
    - software/hardware/maintenance
    - Production and installing the devices?
    - Implementation of the platform?

IoT platform

- Whose bandwidth and server capacity is the customer using when using the platform?
  - Can this be a bottleneck at some point? With the provider or with a single customer?
    - If yes, is there a solution for it?

        - Could the data be filtered already in the device level to save bandwidth?
- Is it possible to take new device providers to the existing platform in the future?
- Would it be possible to connect the platform with an existing platform or information system of a customer?
    - Or could the platform transfer data automatically into customers own information systems?
- How are the customers located on the platform?
    - Vertically on the same platform or horizontally on separate platforms?
        - Is a disruption possible that affects every customer?
        - Can a disruption in one customer's equipment affect others?

Upkeeping

- Who is responsible for monitoring the state of the devices and the data they provide?
- How often do the devices need some maintenance?
    - Who is carrying out the maintenance?
- How do you monitor the quality of your own processes?
    - Is feedback collected from customers?
    - How is the quality of the processes/devices measured and monitored?
        - Regarding the platform?
        - Regarding the devices?
- Where is the cash flow coming from? Monthly fee, starting payment, maintenance invoicing?
    - How is the profit divided between hardware, software and maintenance?