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UTILISING INDUSTRIAL INTERNET IN PRODUCT MANAGEMENT

Master's Thesis

ABSTRACT

There has been a lot of interest in Industrial Internet of Things lately. Its applications and their benefits have generally been widely researched, but the internal applications that product management use have not been sufficiently studied. In this thesis I study how product management can use and benefit from Industrial Internet of Things. I explore the different needs of product management, as well as different Industrial Internet applications and their benefits, to find how the needs could be fulfilled with the applications. I also use lean wastes and value to measure their benefits.

All of product management's objectives require information to aid in decision making. Some of the most important available information include customer information and product usage information. Industrial Internet can be used to build monitoring level applications that produce that information. Some of the most important applications include usage based customer segmentation, product faults analysis and sales support applications. These applications have been used as case studies in this work.

Lean waste categories are good way of quantifying and evaluating the benefits of Industrial Internet applications. When the traditional manufacturing type waste categories are combined with information management waste categories, the different efficiency gains are easy to categorize. By estimating the value of the wastes and additional value created by the applications, as well as the costs of building the application, it is possible to evaluate their profitability.

In both literature and empirical part, it was found that some of the information needs of product management can be fulfilled more efficiently than before, leading to the application being beneficial. They also tend to use the same technology stack as Industrial Internet applications in general, making them interesting.

PREFACE

This thesis explores the use and benefits of Industrial Internet applications in product management organisations.

Kuopio, 24.11.2017

Veli Myllylä

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APPENDIX A: Interview Questions

LIST OF ABBREVIATIONS

CRM	Customer Relationship Management
EPOSS	European Technology Platform on Smart Systems Integration
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Load
GDP	Gross Domestic Product
IIOT	Industrial Internet of Things
IOT	Internet of Things
VoI	Value of Information
WEF	World Economic Forum

1. INTRODUCTION

1.1 Background

The internet of things (IOT) has many definitions. European Technology Platform on Smart Systems Integration (EPOSS) (2008) defines the internet of things as "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols." This work studies the part of the IOT called the industrial internet of things, or the industrial internet. This internet is used in industrial services and can create huge amounts of data that can be analysed or used for other purposes. (Accenture 2015)

Porter and Heppelmann (2014) introduced a new technology stack for the internet of things. This technology stack presents the technology infrastructure that is needed for industrial internet products. The different layers of the technology stack include the software and hardware related to the product, connectivity, server applications, identity and security, external information sources and integration with business systems. These will be presented in more detail in chapter three of the work.

According to World Economic Forum (WEF) (2015) industrial internet is still in its early stages of development. In their survey they found that 88% of responders did not understand business models related to the industrial internet or what its long-term implications to their industry will be. Accenture (2015) reports different estimates of spending related to the industrial internet ranging from $500 billion by 2020 to $15 trillion of global GDP by 2030. They also report that Cisco predicts that there will be 50 billion connected things in the internet of things in 2020 compared to the 25 billion in 2015.

This research is made for a large metal industry company. The interviews and data used in this research are also from this company. The company's revenue is over 100 million euros and it employs over a thousand people. Most of the company's products are not connected to the IOT, but the amount connected to it has quickly grown larger. The company works worldwide, and the products connected to the IOT can be found from every part of the world. This company will be referred to as "target company" or "the company" in the research.

According to Porter and Heppelmann (2014) the business functions affected include product development and marketing and sales. Much of the potential gains come from different types of analyses which can be used to improve product planning, market segmentation and even create new business models. In the target company many of these functions

are managed in the product management. Thus, it is important to study the potential applications and implications of industrial internet in product management.

1.2   Research Problems

The target company has heavily invested in industrial internet technology. That technology and the data gathered from the devices is used by some other parts of the company, but the company's product management does not currently benefit from it. The main purpose of this thesis is to change that and to explore different possible internal applications for industrial internet within a product management organisation. Thus, the main research question is:

How should industrial internet be utilised in a metal industry company's product management?

There are several things that need to be considered when answering this question. First of all, it is important to find as many potential applications as possible. Most of the applications will not be feasible either because they will not benefit the company enough or it is too hard or costly to gain the benefits of the application. The applications also need to answer problems found in the company's product management, so it is important to study the needs of product management.

1)   What are the needs in product management that can be answered with industrial internet applications?
2)   What are the possible applications of industrial internet in the target organisation?
3)   What are the benefits of those applications?
4)   What are the prerequisites to realise the benefits?
5)   How can the value of the benefits be evaluated?

To keep the amount of work suitable for a master's thesis I will only study the three most promising applications even though other applications will also be considered. The purpose of the work is to explore different options of using industrial internet in product management. A very detailed technical study of each application will not be needed for this purpose, as mainly the prerequisites and benefits are of interest. Thus, further limitations to the scope of the work will not be needed.

1.3   Research Methodology

The research consists of two parts. The first part is a literature review of the subject and the second part consists of interviews and case studies done in the target company.

According to Saunders et al. (2009) a research can either have a deductive or an inductive approach. In deductive approach the literature review is used to identify theories and ideas

which are then tested using data. In inductive approach theories and ideas are generated from data and which are then related to the literature. A mixture of both is also possible and that is what will be done in this research. (Saunders et al., 2009)

This thesis uses the literature review mostly to identify possible industrial internet uses, their benefits and prerequisites and thus mostly uses the deductive approach. The data gathered will, however, be also analysed for possible new ideas. In these cases, the new ideas will be related to the literature, so the research does not purely rely on the deductive approach. Literature reviews can also be useful for discovering new research opportunities and it is also one of the main purposes of the literature review in this work. (Saunders et al., 2009)

I will use article databases to gather material for the literature review. The databases used are the following:

- Nelliportaali
- Emerald Insight
- Google Scholar
- Scopus
- TUTCAT

Both Nelliportaali and TUTCAT are available through Tampere University of Technology.

The keywords used to search the articles and books from the databases will be refined throughout the literature review, as Saunders et al. (2009) mention in their work. The initial ones used are combinations of the following:

- "internet of things" or "industrial internet"
- "product planning"
- "product management"
- Benefits and requirements
- "association rule mining"
- Lean wastes
- Information management
- Lean information management
- Software product requirements
- Industrial internet prerequisites

The research does not solely rely on literature review. Data and information will also be gathered by interviewing the target company's employees and by mining and analysing data from the target company's systems.

Interviews will be held to find the needs of the target company's product management as well as to evaluate which applications are the most promising for the target company. The

practicality and value of the possible applications will also be evaluated through interviews. According to Saunders et al. (2009) unstructured interviews are especially useful when gathering in-depth information and knowledge about a certain subject. As the interviews for this research aim to do that they will be unstructured and open.

Each application studied in this research will be also tested by using a case study. The data for the case studies is gained from the target company. The purpose of the case studies is to verify that the ideas found from other sources are practical and can yield the benefits attributed to it. The data for the case studies will be analysed using different analysis tools including SAS. The quality of the data will also be analysed.

1.4   Thesis Structure

I will begin the thesis by introducing the reader to the main topics and presenting the research problem and questions. After that the methodologies used for the research are presented. After the introduction I will study the needs of the product management organisation as its needs narrow the scope of the study and are essential to know to be able to answer the research question. Then I will continue to IIOT and its benefits and prerequisites to create a model for evaluating the usefulness of the applications. This model will later be applied to the case studies in chapter six. In chapter seven I will discuss the results and conclude the work.

2. NEEDS OF PRODUCT MANAGEMENT

There are several definitions to product management. The one used for this study is Chunawalla's (2009) definition. According to him

"Product management is thus that part of marketing management which concerns with product planning and development and is now extended to brand building and management."

In this chapter I will first study what product management is and what are its roles and responsibilities. This will give context to the later parts of this work, as the Industrial Internet applications studied must be relevant to product management. In the second part of this chapter I will study what kind of information and knowledge is needed in product management. This will later be used to evaluate if an application is feasible. This chapter is mostly based on Chunawalla's (2009) work.

2.1 Product Management Responsibilities

One of the research questions of this work is "what are the needs in product management that can be answered with industrial internet applications?" To answer the question the responsibilities and needs of product management need to be understood. Later, in chapter six and seven, this information is used to evaluate the use cases studied. This chapter starts answering the question by studying the responsibilities and tasks of product management, and the next chapter continues it by studying the different information needs of those responsibilities.

To understand product management and its responsibilities it is good to first study what a product is and what it consists of. According to Chunawalla (2009) a product consists of the following components:

- physical attributes
- services and after-sales-service
- brand
- brand image
- intangible or psychological benefits
- product safety
- guarantee/warranty and
- special features

The importance of the components might vary between products. For example, a service product might not have a physical component. The components are quite similar between

different sources. A product manager is responsible for these components and their development. (Chunawalla, 2009; Maglyas et al., 2013)

A company's products form a product mix, or product portfolio, which needs to be managed by product management and the company's upper management. A product mix consists of product lines. A Product line is a group of products closely related to each other in a company. Product lines consist of product types and product types consist of individual product models. For example, a company might have three product lines: computers, phones and televisions. Televisions product line could consist of two product types: LED televisions and LCD television. A product group in turn would consist of individual television models inside the group. Product line's length means the number of products in a product line and its depth is the number of product types in the product line. Product line stretching means adding new products to the product line that are higher or lower quality than existing products. (Chunawalla, 2009)

To manage the product and its components product management includes a set of activities related to product planning and management. A product plan defines products strategy, by defining product line length and depth, as well as line stretching. It considers both existing and new products, their places in product portfolio and their way of creating and delivering value. (Chunawalla, 2009)

According to Chunawalla (2009) product management generally has seven objectives. These are:

1. designing product strategies
2. spotting marketing opportunities and analysing if they are exploitable
3. seeking growth through new product development
4. planning strategies for different parts of product lifecycle
5. generating new product ideas and developing them
6. managing product portfolio
7. managing and building brand image, position and value

The objectives aim to create value for the customer in an efficient way. Customer value is created by the components of the product. Thus, the objectives of product management aim to optimize the product's components. To be effective the activities and objectives need to be aligned with each other and the corporate strategy. (Chunawalla, 2009) Other authors have slightly different views of the objectives, and for example Ebert (2006) factors the tasks into the following four areas:

1. Business objectives and accountability
2. Mastering requirements
3. Managing risks and uncertainty
4. Leadership and teamwork.

As can be seen the views of Chunawalla and Ebert are quite similar, though Ebert also includes more human aspects with leadership and teamwork. As those aspects might be difficult to support with information coming from IoT, they are outside the scope of the work, even if they are potentially important. Maglyas et al. (2013) have similar views, but also mention that the roles of product management vary between organisations, so definite listing is impossible to make. For the purpose of this work the listing of Chunawalla (2009) is used.

A product manager works as a facilitator between different departments of a company. Product management and its four most important relations to other departments of a company are presented in figure 1 which are gathered from the works of Gorchels (2000), Chunawalla (2009) and Ebert (2006).
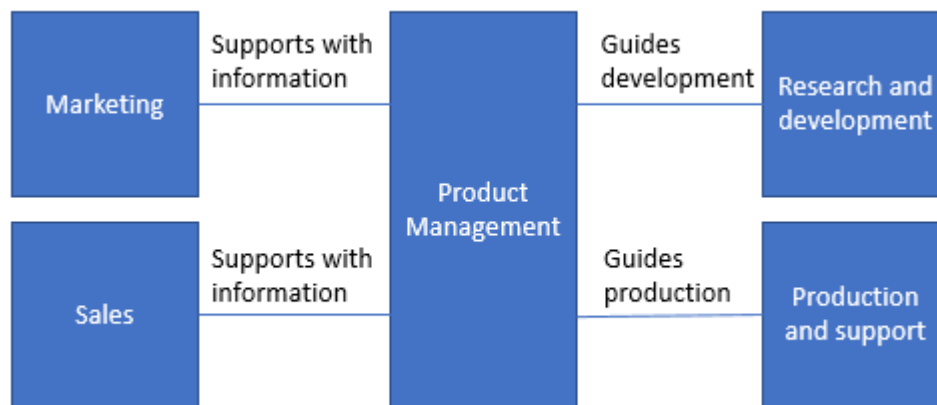
Figure 1 Product Management Contacts

According to Gorchels (2000) the highest level of contact towards. It is a two-way contact, where sales provide product management with important market and customer information and contacts, and product management supports with product information and training. Gorchels argues in her work, that the most important types of contact to sales are the following:

- Sales training covering product knowledge, and market and competitive intelligence. Product training also covers sales arguments for different products.
- Sales planning, including ideal target customers, segments, and markets for each product.
- Qualifying needs – product manager must provide sales with information or set of questions on how to determine the appropriateness of a sale. Customer satisfaction is highly dependent on customer's needs matching with a product's benefits.
- Customisation of solution – when should a product be customized for a customer and how?

The main purpose of the contact is to help sales sell the correct product with the right price to a customer, help promote new features and products and pass knowledge from sales to product management. Comparing these tasks to Chunawalla's (2009) objectives, we can see that they fall under nearly every objective, but when looking at the information passed to sales from product management, they mainly belong to the 2nd and 7th objectives

Marketing is more one-way contact than sales. According to Gorchels (2000) product managers decide what a products positioning should be, but how to communicate that is left to marketing professionals. The main function of the contact is to build and communicate brand value, though marketing will also help identify marketing opportunities. When looking at the information passed on by product managers to marketing the contact seems to mostly fall under the 7th objective.

When interacting with research and development the main role of the product manager is to represent customer's voice and balance customer value and needs against costs and the company's return on investment. This requires the product manager to understand how products are used, what the product's value to the customer over its lifecycle is and how the products could be improved. Research and development include strategical decisions to the products and product lines. (Gorchels, 2000; Chunawalla, 2009) Comparing the interaction to the seven objects by Chunawalla, interaction with research and development would seem to belong to every of them.

Finally, product manager works with production and support functions. From information perspective the main interaction is communicating and fixing possible errors, claim and warranty issues, and faults in the products, with especially warranty issues requiring possible training and support from product management. (Gorchels, 2000) This interaction mainly serves to better service quality, thus falling mostly to the 7th of Chunawalla's (2009) objectives.

A project manager is responsible and accountable for a project and its planning and execution. Work with project managers can be part of any of product managers task. Often the purpose and requirements of the project manager's project come from a product manager. Different types of projects in which a product and project manager will often cooperate include be product development, sales and marketing, delivery and maintenance projects. (Gorchels, 2000; Ebert 2006)

2.2   Information Needs

Understanding the information needs of product management is crucial in order to understand and value the benefits of industrial internet applications. In chapter three the different needs found in this chapter will be combined with industrial internet applications to

find which needs those applications answer to. Then in chapter four these will be combined with different benefits to form a model that is used to evaluate the empirical case studies.

The knowledge needs of product management can be derived from its seven objectives.

First one of the objectives is designing product strategies. According to Chunawalla (2009) product strategy should be designed with respect to customer, industry and competition analysis. Detailed information on market and existing products, customers and customer segments is needed.

Second objective is to spot marketing opportunities and to find out if they can be exploited. Spotting marketing opportunities requires detailed information on market. Like with the first objective, customer segmentation and understanding customer needs is important in this. (Chunawalla, 2009; Porter & Heppelmann 2014)

Third objective is seeking out growth through new product development. According to Hines et al. (2006) understanding customer needs is a fundamental starting place to new product development. In addition to customer needs, it is important to understand how the new product creates value to customers. According to Chunawalla (2009) customer value is derived from the product, service, personal and image value created by the product and from its total costs. Womack & Jones (2003) argue, that value is the reason why product exists from a customer's point of view. According to Porter and Heppelmann (2015) value created by a product can be understood by gathering and analysing customer, sales, cost and product usage data. Chunawalla (2009) agrees with Porter and Heppelmann in that part of creating customer value is knowing customer and their needs.

Fourth objective is to plan product lifecycle strategies for all parts of product lifecycle. According to Hines et al. (2006) product lifecycle consists of new product development, product launch, mass production and its marketing support, delivery, product upgrades and development, repair and after-sale service and retirement of products. Product lifecycle management requires understanding the different parts of the lifecycle. Among other information, information on current performance, technology, market dynamics, customer and shareholder requirements and value, corporate strategy and business models is required to plan lifecycle strategies. (Hines et al., 2006)

Fifth objective is to generate new product ideas and developing them. As with the third object, it is important to understand customer needs and how the product creates value to a customer. It is also important to analyse current quality problems with a product. (Chunawalla 2009) Information on product usage, claims and warranties are useful for this purpose. (Porter & Heppelmann 2015)

Sixth objective is managing product portfolio. According to Chunawalla (2009) product portfolio is managed by making decisions on product line length, width and stretching.

This is done by ending an old product, introducing a new one, or changing a product's components. To effectively manage portfolio understanding on what needs to be changed is needed, as such creating portfolio analysis is an important part of portfolio management. According to Wind and Mahajan (1981), when creating a portfolio analysis, customers' perceptions, preferences, and usage of various products should be combined to market, or industry, segments. Additionally, distribution and geography should be included to portfolio analysis when distribution system figures are important to the company's marketing mix.

Seventh and last objective is managing brand, its value, position and identity. According to Chunawalla (2009) a brand has hierarchy of attributes, benefits and values that it must manage. What a brand stands for is stated in the attributes, which it then explains and rationalises by providing rational and emotional benefits. To be able to effectively communicate the value and benefits of the product they need to be understood. An understanding on market and different customer segments is crucial for this task. This objective is highly connected to the sales and marketing support functions as presented by Gorchels (2000). According to her the main information needs for this include market, product and customer information, sales arguments and competitive intelligence.

The objectives and their information needs are condensed in table 1. below.

Table 1 Product Management Objectives and Information Needs

Product management objective	Information need
Designing product strategies	Market information, customer and customer segment information
Spotting marketing opportunities and analysing if they are exploitable	Customer and customer segment information, customer needs
Seeking growth through new product development	Customer and customer needs, sales, cost and product usage data
Planning strategies for different parts of product lifecycle	Current product performance, technology, market information, customer and shareholder requirements and value, corporate strategy and business models
Generating new product ideas and developing them	Customer needs, product usage, claims
Managing product portfolio	Customers' perceptions, preferences, and product usage, corporate and product strategy, market information, customer needs and segments
Managing and building brand image, position and value.	Market information, customer needs, product value, product information, sales arguments, competitive intelligence

3. INDUSTRIAL INTERNET

The Internet of Things (IoT) has many definitions. European Technology Platform on Smart Systems Integration (EPOSS) (2008) defines the Internet of Things as "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols." IoT includes a large amount of very different usage applications. For example, consumers and companies often have different ways of using and benefiting from IoT. Industrial Internet (IIOT) is the part of the Internet of Things that is used in industrial services and can create massive amounts of data that can be analysed or used for other purposes. (Accenture 2015)

In chapter 3.1 I will first study what industrial internet is and what it is composed of. This information will later be needed to find the prerequisites of an internet of things application. After that, in chapter 3.2., I will study how business models are affected by Industrial Internet. Understanding the different business models will help to evaluate what benefits different applications might have. In chapter 3.3 I will explore the different internal applications Industrial Internet enables. In this work internal application means the type of applications that mostly benefit the company itself rather than directly changing how a customer's product functions. These will then be compared to the needs of product management found in the previous chapter.

3.1 Structure

Understanding the structure of Industrial Internet is crucial to understand the possibilities and requirements of such systems and their applications. According to the work of Porter and Heppelmann (2015), on a logical level the components in IIOT systems include data sources and collection, data storage, and analytics, as shown in figure 2 below.
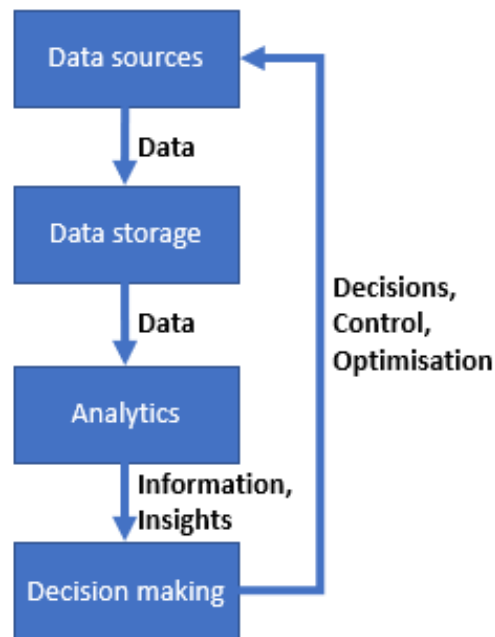
Figure 1 IIOT Value Creation

At the core of all IIOT systems is data. There are several possible data sources to use for analytics and other purposes, including:

- Data from a company's internal systems, like enterprise resource planning system, or its customer relationship management system
- External data sources, including thing such as price and weather date, or data from 3rd party operations
- Data from devices, like the devices location, measurement values of its sensors, its condition and data on how it is used

The first two data sources have been available for a longer time, but before the era of smart, connected devices it was difficult to gather data of how products are used and how they function. This new data source requires high speed connectivity, devices with large amounts of processing power, and the ability to handle huge data masses. The enablers of this data source are the recent advances in connectivity and processing, as well as the miniaturisation of devices and cheapening prices of the components and connectivity. (Porter & Heppelmann, 2014; Porter & Heppelmann, 2015)

The second part of the model is data storage. Connecting the data from the three data sources can create more value than only using data from single source. To do this, Porter and Heppelmann (2015) suggest the use of data lake to aggregate the data from different sources. To get the data to the data lake different kinds of software tools and high-speed connectivity are needed.

From within the data lake the data can be used for different purposes, the most important for IIOT value creation being analytics. Analytics is a wide area with many different tools, functions and purposes. Different IIOT applications are enabled by different types of analytics. Analytics can be classified into four groups by their function from the least complicated to the most:

- Descriptive analytics, which in the context of IIOT means capturing and monitoring products operation, condition and environment to find out what has happened or what is currently happening
- Diagnostic analytics answers the question of why something has happened by analysing the product's data. Diagnostic abilities can, for example, be used to examine why a product has failed
- Predictive analytics tries to find out what will likely happen in the future by finding patterns in data and then comparing the product's usage data to the patterns found to look for similarities
- Prescriptive analytics is used to analyse what should be done about something when it happens. This can be done by identifying measures to improve outcomes and correct problems.

The first two groups are focused in current time, or in the past. The latter groups, on the other hand focus on predicting the future and affecting it. To be able to predict the future, it needs to be possible to gather data about the past, thus making the grouping hierarchical, in that the next tier requires the abilities of the previous ones. (Banerjee et al., 2013; Porter & Heppelmann, 2015) There are many things to consider with big data analytics, like which models or learning types to use. Mostly these decisions, while important, do not affect the basic value creation process of Porter and Heppelmann (2015). However, the of choice computing platform and processing method might affect it (Sharma & Wang, 2017).

With the rise of edge computing, and stream analytics and processing, the model suggested by Porter and Heppelmann (2015) is not the only common way of creating value with IIOT systems. Edge computing, or fog computing, is a computing platform where calculations and analytics are done at the devices instead of in the cloud. This can lessen the need for big data storage, or data lake, and in some cases, change the places of data storage and analytics in the model. Economically this is interesting, since data communications and storage for large quantities of data can be expensive or difficult to build. Some applications also require low response times that are difficult to achieve with cloud computing. (Rehman, et al., 2017; Sharma & Wang, 2017)

Stream computing and analytics are processing methods, which mean doing computations or analytics straight in the data stream without storing it first. Similarly to edge computing, stream processing and analytics reduce the need for data storage, and can in some

cases combine the analytics and decision-making phases of the process. (Rehman, et al., 2017; Sharma & Wang, 2017) Value creation is considered more in chapter four.

Last part of the process is decision making based on the analytics. In this phase business, customer or partner uses the insights gained from analytics to create value to some part of the value chain. From IIOT point of view this often includes changes to product, by the means of optimisation or control. (Porter & Heppelmann, 2015)

Different types of products with intelligence and limited connections have existed for some time already. From Porter and Heppelmann (2015) we can gather that the important functionalities of an IIOT system are smart product with connectivity, and cloud service where the data, analytics and possibly control of the device fleet is concentrated to. These differ from earlier systems in that the device fleet is centrally controlled over a distance, making central connectivity and intelligence of a device fleet the defining features of Industrial Internet, which is in line with the EPOSS (2008) definition. (Porter & Heppelmann, 2014; Porter & Heppelmann, 2015))

On more technical level Industrial Internet applications generally consist of at least the three basic components of product cloud, connectivity and devices and sensors. The system includes both hardware and software components on each level. Porter and Heppelmann (2014) introduce a detailed description of such system in the form of a technology stack that supports the Industrial Internet value creation process. This technology stack is shown in figure 3 below.
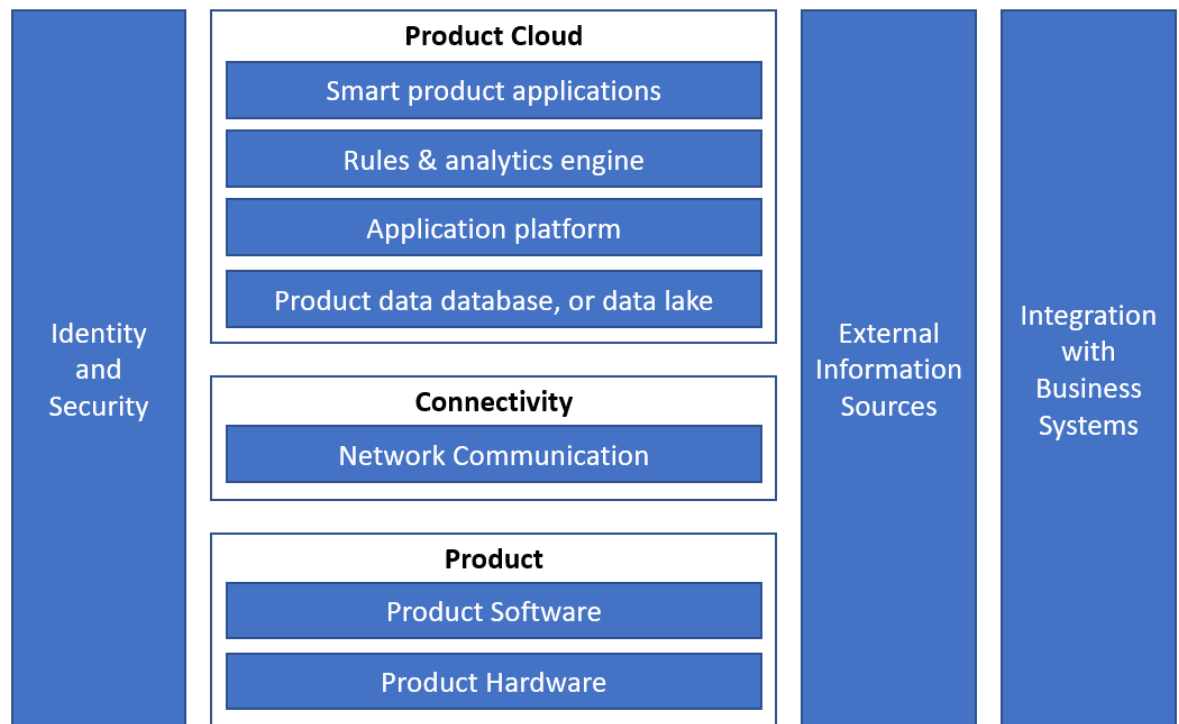
Figure 2 IIOT Technology Stack

The technology stack describes the components of an internet of things system. At the base of any Internet of Things, or industrial internet, application are smart devices and sensors. They gather the data, which is then sent to other devices and to cloud services using some type of connectivity. The devices may also react to the data they have gathered or that they receive from other devices. The cloud service receives the information and uses it for various tasks, like analysing device usage. In some cases, the device cloud also controls the devices connected to it. (Porter and Heppelmann, 2014)

The first part of the technology stack consists of the smart product, including both its software and hardware. Hardware includes sensors, processors, mechanical and electrical components of the product and connectivity port or antenna that is part of the product. Software includes software running on the product, including operating system, product control software, possible user interface and any software applications running on the products hardware. The product, its sensors and software, is a limiting factor to what can be collected and thus to what kind of applications are possible. According to Noronha etl al. (2014) and McFarlane et al. (2013) some of the analysis and data handling needs to be done by the product software, especially when an IoT application is highly distributed, due to limitations in connectivity.

Second part of the technology stack is connectivity. It is the system that connects the smart product to the cloud. It includes both software and hardware components, like network protocols, routers and so on. It is crucial to the system and can cause limitations in

possible applications if, for example, large amounts of data cannot be transferred or if data cannot be transferred in real-time. (Porter & Heppelmann 2014, Noronha et al. 2014)

Third part of the technology stack is product cloud, which consists of four parts: product data database, application platform, rules/analytics engine and smart product applications. Product data database is usually a big-data database system, like Hadoop. It enables storage, aggregation, normalization and management of historical and/or real-time data. It utilizes an ETL (extract, transform, load) system, to collect, normalize and manage data from several databases. Being able to store large amounts of historical data is crucial for many applications, as found in chapter 4. Thus, a scalable database system capable of handling big data is often needed. (Porter and Heppelmann, 2014; Gubbi et al., 2013)

Application platform is an application development and execution environment. It is used to quickly create business applications to utilise the Industrial Internet technology. (Porter and Heppelmann, 2014) To be able to benefit from the data gathered from a product it needs to be analysed. This is done with a rules and analytics engine. According to Noronha et al. (2014) more powerful analytics tools were the biggest technological enabler in an Industrial Internet system. Last part of the product cloud is smart product applications. They are software running on remote servers instead of in the product, and can manage different product functions remotely. (Porter and Heppelmann, 2014)

There are three additional layers that can affect the aforementioned layers. Firstly, the identity and security layer affects all the previous ones, as the data transferred and used is often sensitive and needs to be protected. Many applications and uses of Industrial Internet require external information sources. These can include sources such as weather or climate data, prices and costs, or geomapping, for example. Lastly there is integration with business systems, such as ERP (enterprise resource planning) or CRM (customer relationship management). Data from such systems is often a prerequisite for an industrial internet application. (Porter and Heppelmann, 2014) As these three layers mostly bring prerequisites to an Industrial Internet application, they will be studied in more detail in chapter 4.

There are other approaches to the IoT technology stack in literature as well. For example, according to Gubbi et al. (2013) there are three components:

1. Hardware, which is made up of sensors, actuators and communication hardware
2. Middleware, which includes on demand storage and computing tools for analytics
3. Presentation, which includes visualization and interpretation tools

While Gubbi et al. (2013) and other sources (SAP, 2014; McFarlane et al., 2013…) have different approaches to the structure of an IoT system, the basic idea behind them is similar. Porter and Heppelmann's (2014) model is quite detailed compared to the other models and will be used in this work.

3.2   Internal Applications

The second research question is "What are the possible applications of industrial internet in the target organisation?" The purpose of this chapter is to explore different types of IIOT applications, so their benefits can be evaluated in chapter four and then tested with the case studies.

According to Porter and Heppelmann (2014) the capabilities of Internet of Things applications can be divided into four areas, which are monitoring, control, optimisation and autonomy. The four areas build on top of the previous one, causing the next level to always require the capabilities of the previous level. Figure 4 below is modified from Porter & Heppleman's (2014) work and present the four layers.
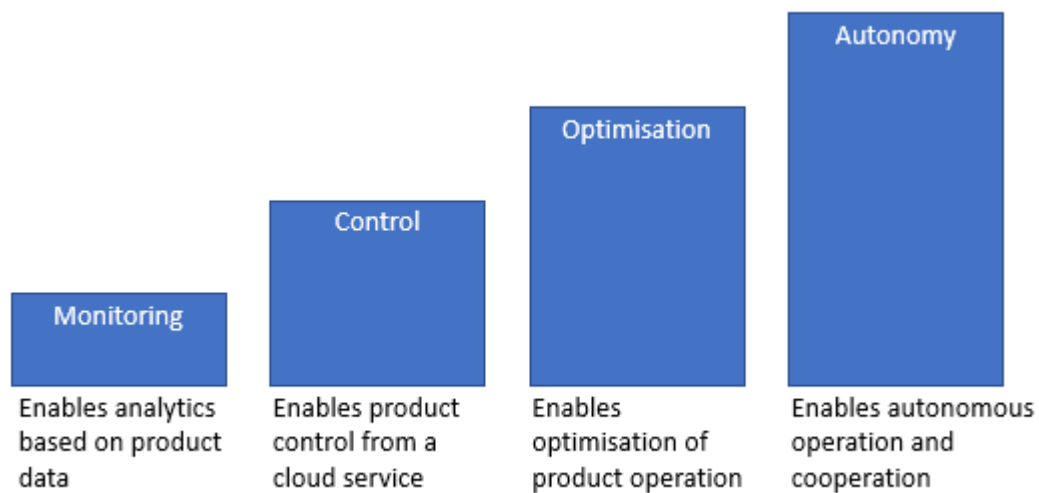
Figure 3 IIOT Capability Levels, adapted from Porter & Heppelmann (2014)

Monitoring capabilities allow a company to track a product's operations, condition, and/or environment. This data can be used to better understand how and where the product is used, but the device cannot yet directly be affected from the product cloud. Monitoring capabilities at their core are gathering, analysing and utilising data to gain actionable information. (Porter & Heppelmann, 2014) The product management tasks found in the previous chapter mostly benefit from information, so in the case of product management the main benefits are also going to come from lowest level of IIOT capabilities. The value of monitoring capabilities comes from analytics and include all the four different kinds of analytics, descriptive, diagnostic, predictive and prescriptive, mentioned by Porter and Heppelmann (2015).

Control capabilities are the next step up from monitoring. They enable remotely using or controlling a connected product through the product cloud. Control capabilities also include a smart product's ability to react to changes in its environment. The input for the reaction comes to the product cloud using monitoring level capabilities, to which the

cloud responses using an algorithm or rule, and then sends a control command back to the device. Since control in IIOT applications often comes from the product cloud, a high-speed connection is needed for reliable control capabilities. (Porter & Heppelmann, 2014)

Optimisation combines monitoring and control capabilities to enable product optimisation, potentially enhancing product performance and allowing predictive diagnostics, service and repair. Optimisation mainly differs from control level capabilities in that it requires and utilises higher level of analytics capabilities. (Porter & Heppelmann, 2014)

Autonomy level combines the lower level capabilities to enable a product to operate autonomously and self-coordinate with other systems or devices, autonomous product enhancement or personalisation and self-diagnosis and service capabilities. It is the most advanced level of the model. With autonomous level system humans simply monitor the device fleet, in which the devices work and optimise their work independently. (Porter & Heppelmann, 2014)

Control, optimization and autonomy capabilities bring valuable benefits and opportunities with them, but are mostly not geared towards solving product management's problems. The seven objectives of product management found in the last chapter are:

1. designing product strategies
2. spotting marketing opportunities and analysing if they are exploitable
3. seeking growth through new product development
4. planning strategies for different parts of product lifecycle
5. generating new product ideas and developing them
6. managing product portfolio
7. managing and building brand image, position and value. (Chunawalla, 2009)

While the work and processes of product management might be affected by the control, optimization and autonomy stages of the industrial internet capabilities, they will not be considered more in this study, since they don't give tools to better fulfill the seven objectives and their information needs. Monitoring capabilities, however, provide information and knowledge that can be invaluable for product management, especially when combined with data from other systems (Porter & Heppelmann, 2015).

There are tens of different applications for monitoring level Industrial Internet applications. To keep the list shorter, I will only mention applications that could answer to product management's needs. Thus, some major applications, such as enabling predictive maintenance will not be mentioned. Different monitoring applications found by Porter and Heppelmann (2014, 2015) include the following:

1. market/customer segmentation
2. analysing usage for product planning and design
3. creating sales opportunities

4. validating warranty claims
5. analysing product faults
6. communication of product value to customers

Other sources (Gubbi et al., 2013; McFarlane et al, 2013, Haller et al., 2009) also list some of the applications mentioned by Porter and Heppelmann, and provide the following uses:

7. accident monitoring and emergency response coordination (Gubbi et al., 2013; McFarlane et al, 2013)
8. creating new strategies and predictions (Haller et al., 2009)

Customer and market segmentation generally means identifying and grouping customers. This approach assumes that there are different groups in a given market distinguished by their wants, needs or some other attribute. There are several ways to doing customer segmentation and the best way varies depending on the situation and intent. One approach is to group customers by their needs and wants. This information has been difficult to access before, but the usage data that can be collected from Industrial Internet can be analysed for usage patterns, which in turn reveal much about customer's needs. Another approach is to segment the market by industry, organisation, country, or by other similar attribute. (Harrison & Kjellberg, 2009; Freytag & Clarke 2001; Porter & Heppelmann, 2014) As found in chapter 2, customer and market segmentation are useful for product management in all its activities, as it can help product management understand the value its products create.

Analysing usage for product planning and design is a monitoring level application, requiring diagnostic level abilities. The information gained includes better understanding of how products are used and operated, and how they act in different situations. When compared to the specifications used for designing, it might be possible to find for example overengineering, or other types of waste. Products might also be used in ways different from planned, which might require changes to design specifications to create better quality products. (Porter & Heppelmann, 2014)

Monitoring data could also be used to identify customers with heavy product usage, who might be need additional products (Porter & Heppelmann, 2014). Creating sales opportunities mostly goes outside the scope of product management, but the type of information generated can also be useful for marketing purposes, especially when combined with customer segmentation.

Product management is often responsible for product quality (Chunawalla, 2009). As such validating warranty claims can provide useful information. Analysing product faults and product usage can help product management understand why products break. This can be done by finding correlations between product usage and product faults using statistical methods or by finding patterns in data of failing products. The knowledge

can be used to improve quality and reduce claim related costs. (Porter & Heppelmann, 2014; Porter & Heppelmann, 2015)

This same type of information is useful for validating warranty claims also. If descriptive level analytics can be applied to product usage data of devices that are target of warranty claims, it is possible to check if product usage has violated warranty agreements. (Porter & Heppelmann, 2014)

Communication of product value includes giving customer rational reasons to buy a product or product option. Such sales arguments can be analysed from product usage data by comparing it to different products. For example, finding differences in product performance, lifetime or uptime can be turned into money gained by the customer, thus justifying higher cost of a product. The differences found can be used as marketing material to build and communicate brand value, but the information can also be useful in generating new product ideas, spotting marketing opportunities and when creating product strategies. (Porter & Heppelmann, 2014; Chunawalla, 2009)

Accident monitoring and emergency response coordination is application where failures are being monitored, which enables fast response to them. While useful for other areas, this function is more likely the responsibility of maintenance, or someone outside of product management. (Gubbi et al., 2013; McFarlane et al, 2013) Since it produces information on product faults which is useful for product management as well, it has been merged with product fault analysis for this work.

Creating new strategies and predictions through information generated by IIOT applications is possible due to the visibility to real world created by near real-time data from devices. The usage and sensory data generated can be combined with enterprise data and analysed to discover patterns and trends in use of different products. This business insight can be used to predict changes in how products are used and create new strategies based on that. (Haller et al., 2009)

As mentioned by Porter & Heppelmann (2015), the core value of the applications comes from the data and information gained from it through processing and analysing it. The information gained from the applications above are condensed into the table 2 below.

Table 2 IIOT Applications and Information Gains

IIOT Application	Information gained

Market/customer segmentation	Customer needs and usage patterns in different market/customer groups
Analysing usage for product planning and design	How the current product can be improved, are the products used like intended, is there waste
Creating sales opportunities	Marketing target groups
Validating warranty claims	Are the warranty claims valid, how to spot invalid cases
Analysing product faults	Why do products fail, are there patterns in how products fail
Communication of product value to customers	Sales arguments like product performance differences, value of the differences
Creating new strategies and predictions	Product usage insights, trends and patterns

When the information provided by the applications is compared to that required by the product management tasks found in the previous chapter, it possible to combine the applications with product management objectives. This information is especially interesting when answering the research question of "What are the needs in product management that can be answered with industrial internet applications?" Product management objectives and the applications that could answer their information needs are combined in table 3 using the information needs and gains as common variable.

Table 3 IIOT Applications addressing Product Management Objectives

Product management objective	Information need	Application
Designing product strategies	Market information, customer and customer segment information	Customer segmentation, Creating new strategies and predictions, Communication of product value to customers
Spotting marketing opportunities and analysing if they are exploitable	Customer and customer segment information, customer needs	Customer segmentation, Creating sales opportunities, Communication of product value to customers
Seeking growth through new product development	Customer and customer needs, sales, cost and product usage data	Customer segmentation, Creating new strategies and predictions
Planning strategies for different parts of product lifecycle	Current product performance, technology, market information, customer and shareholder requirements and value, corporate strategy and business models	Analysing product faults
Generating new product ideas and developing them	Customer needs, product usage, claims	Analysing product faults, Creating new strategies and predictions, Communication of product value to customers

Managing product portfolio	Customers' perceptions, preferences, and product usage, corporate and product strategy, market information, customer needs and segments	Customer segmentation, Creating new strategies and predictions
Managing and building brand image, position and value.	Market information, customer needs, product value, product information, sales arguments, competitive intelligence	Customer segmentation, Communication of product value to customers, Analysing product faults, Creating new strategies and predictions

4. CREATING VALUE WITH INDUSTRIAL INTERNET APPLICATIONS IN PRODUCT MANAGEMENT

The first purpose of this chapter is to create a model for evaluating the feasibility of Industrial Internet applications. The feasibility of an application is dependent on the potential benefits gained from the application and how easy or hard it is to realise those benefits. The benefits can be split into two categories – improved efficiency and additional value created. To evaluate the different obstacles of realising the benefits I have studied three prerequisite categories – organisational, data related and technical prerequisites. The second purpose of the chapter is to study different ways an application can affect product management.

Lean concepts are used in many parts of this work and form the base for the theoretical model of this chapter. Lean is a management philosophy which has its origins in Toyota Production System and which was studied and made popular by Womack and Jones in the 1990s. Womack and Jones (1996) identified five key principles of lean. These are:

1. Value is the reason a product exists – it is the benefits and value a product brings to a customer. Value will be explored more in the chapter 4.1
2. Value stream is the set of actions that brings a product from concept to a customer's hands. Mapping the value stream is used to find which steps in it create value and which could be eliminated as waste
3. Flow means that after removing waste from the value stream its value generating steps should be made to flow smoothly without interruptions
4. Pull means that the requirements and production should be based on customer pull, instead of pushing new features and productions to customer
5. Perfection is continuous improvement. It is striving for perfection by improving value and systematically reducing waste over time.

The most important lean term for this work is "muda", or waste. Waste is an action or part of process that does not create value. (Womack & Jones, 2003) The main purpose of many of the Industrial Internet applications is to reduce waste and thus the different waste types will be explored more in chapter 3.1. (Porter & Heppelmann, 2014)

In chapter 4.1 I will first study how IIOT applications can create customer value through product management, and then identify the different waste categories that can be affected by them. In chapter 4.2 I will study the challenges and prerequisites of IIOT applications to identify the possible obstacles and costs related to applications. In chapter 4.3 I will

evaluate the feasibility and profitability of IIOT applications by using the tools from chapter 4.1 and 4.2 to assess gains and costs.

4.1 Industrial Internet Benefits and Value

Value creation and waste reduction are the two ways an application can be beneficial. The third and fifth research questions are what are the benefits of IIOT applications in product management and how can those benefits be evaluated. This chapter aims to answer to those questions by examining both value creation and waste reduction and mapping them to the applications from chapter 3. Since the benefits of the applications for product management purposes come from the new information, the evaluation of the value means evaluating the value of that new information.

4.1.1 Creating Value with IIOT in Product Management

According to Womack & Jones (2003) value can only be defined by the customer and it is, from a customer's point of view, the reason why the producer and the product exist. According to Raynor and Cotteleer (2015) the way in which information creates value is different from how traditional services create value.

Raynor and Cotteleer (2015) argue that information value creation has five stages, which are

1. Data creation – which in IIOT means data generated by the product or component with sensor
2. Communication – to be able to utilize the data it needs to be transmitted from one place to another
3. Aggregation – gathering together data from different times and sources
4. Analysis – finding patterns, relationships and other useful phenomena that can lead to useful knowledge that can acted upon
5. Act – acting on the knowledge generated by the IoT system.

As can be seen, this model of value creation closely resembles that of Porter and Heppelmann (2015) studied in chapter 3.1, where communication and aggregation were combined into data storage. Both of them are heavily centered on data creation and analytics to support actions or decision making.

Since the person acting on the knowledge created by IIOT applications considered in this work are from product management, the customer value created is at least mostly indirect, and comes in the form of better product or service. According to Chunawalla (2009), customer value consists of product value, service value, personal value and image value. These in turn are created by the following seven principles:

1. Knowing customers, tailoring services, foreseeing their needs and simplifying the process for customers
2. Minimizing number of people needed for transactions
3. Enabling self-service where possible
4. Offering service packages with products
5. Letting customers design products
6. Delivering product and service competently
7. Building long-term relationships with customers.

Thus, when creating customer value with IIOT applications through product management, the analysed data generated by the devices should help a product manager affect one of the seven principles. Table 3 in chapter three maps the studied applications to the information they produce. Since, apart from validating claims, all the applications found in chapter three aim to produce information that lets the product manager know their customers and products better, they can all potentially produce customer value. The fourth principle could potentially also be enabled by IIOT applications, since they often enable new services, like predictive maintenance (Porter & Heppelmann, 2014).

The customer value created through the first principle is difficult to estimate, since it is indirect and caused by better product management decisions. A better estimate of the value for the company might be how difficult the information would be to obtain otherwise. For that, estimating the waste reduction is a better tool.

4.1.2 Reducing Waste

In lean, waste means doing something without creating value. In other words, actions that do not add value are waste. Some degree of waste is found in nearly any process or system. There are several reasons for recognizing waste in products and processes. Reducing it from the value stream saves resources while producing the same value. Secondly, it is a useful tool for categorizing potential benefits and cost savings generated by different actions.

Lean has traditionally recognized seven or eight different types of waste. According to Womack and Jones (2003) the seven waste types of lean are overproduction, waiting, transport, extra processing, inventory, motion and defects. The original waste categories are meant for manufacturing systems. With IIOT, however, the main benefits come from the new data generated and analysed, so information management waste types might describe the benefits better. The idea behind the traditional manufacturing waste categories is true for information management too, but the categories themselves are different. Table 4 holds the seven waste types found in manufacturing and information management as found by Hicks (2007).

Table 4 Lean Waste Categories adapted from Hicks (2007)

	Manufacturing systems	Information management	Information users
1	Overproduction	Flow excess	
2	Waiting	Flow demand	
3	Extra processing	Failure demand	
4	Defects	Flawed flow	
5	Transport		Mass electronic communication
6	Inventory		Legacy databases and file archives
7	Motion		Gatekeepers/single seat licenses

The first information management waste type is flow excess, which resembles the over-production waste found in manufacturing. Flow excess means having too much data or information in a system. According to Hicks (2007) this can lead to information storage problems and issues with information identification, location and organisation. Often the reason for this waste is that the value of the data is not known, so excessive data is storage. Since not knowing the value of the data is often the root of this problem it can be affected by applications which grant that knowledge. This type of waste can be hard to reduce with Industrial Internet applications and flow excess is more often a problem than the target of such applications, with many sources reporting the amounts of data generated to be possibly problematic (Noranha et al., 2014; Porter & Heppelmann 2014…)

Flow demand is the second waste type recognized by Hicks (2007) and means the time and resources spent to identify what information is needed. Flow demand might be affected by some Industrial Internet applications, but reducing it is rarely their focus. By considering the IIOT application information produced table, table 2, in chapter three, we can see that none of the information really addresses flow demand type problem. Instead, the applications might cause this type of waste during implementation, as it is sometimes difficult to determine beforehand what is the data that should be gathered.

Failure demand is the third information management waste type and includes the resources used to overcome lack of information. This can include the resources used to gather the needed information (Hicks, 2007). failure demand means additional demand or processes created by the failure to resolve a problem at the first opportunity. According to Hicks (2007) failure demand includes issues such as:

- Information does not flow from, so additional resources are needed to acquire the information
- Data needs to be entered into systems manually, generating additional work.

According to Porter & Heppelmann (2014), previously, product usage and state data has only been available through questionnaires, interviews and other similar ways of data collection. The amount of work required to gather the data can be considerable, as interviews and other manual data gathering takes time and effort. Device usage data gained through IIOT applications can in many places replace the old types of data collection, and so reduce failure demand waste. Looking at the information produced table, table 2, of chapter three, all the applications produce this type of data. The extent of resources saved depends on how much work the previous data gathering methods caused.

Flawed flow is the last information management waste type presented by Hicks (2007) and includes resources needed to correct or verify information and unnecessary or inappropriate actions that derive from the use of such information. Reducing the waste caused by flawed flow is one of the main targets of many applications found in this work, as the aim of many applications is to provide information and knowledge for decision making.

Since, earlier, the method of gaining device usage, state and environment data was through questionnaires, interviews, or visits to product site, the data was not always gathered, and it might not have been accurate. Questionnaires and interviews leave room for error and inaccuracies when asked about product usage, especially when it comes to things such as usage before product failure or accident, where the interviewee might have conflicting interests with the company. The data also could not have been as detailed as what is possible through IIOT. (Porter & Heppelmann, 2014) Looking at the information produced table, table 2, from chapter three again, all the applications generate information that might not have been available, or would have likely been more inaccurate before. As such, all the applications potentially reduce the amount of flawed flow. The extent, or monetary value, can be difficult to determine though, due to the nature of the waste. (Hicks, 2007)

In addition to the information management waste types Industrial Internet applications are often used to reduce manufacturing systems waste. Reducing transport and inventory waste types is often the main goal of an Industrial Internet application. (Porter & Heppelmann 2014; Porter & Heppelmann 2015; EPOSS 2008) These are not something product management as defined in this work can affect however, so they will not be considered in more detail. Extra processing and defects, however, are waste categories that can be affected by product management.

Extra processing means more work or higher quality than what is required by the customer. Higher than needed quality often requires more work or materials, thus causing waste. (Womack & Jones 2003) Industrial Internet applications can be used to reduce this kind of waste in several ways. According to Porter and Heppelmann (2015) IoT can reduce variability of a product, by using digital tools to limit products instead of hardware. Also, as found in chapter three, IIOT applications can create a better understanding of how products are really used. This knowledge can be used to set the standards towards

which the products are designed to reduce too high quality. With its power over product mix and lines, product management can also add or reduce the number of products, and target them to suit usage groups based on IIOT data, to decrease the amount of extra processing (Chunawalla, 2009).

Defects are finished goods or services that do not fulfill the needs of a customer. There are many possible reasons for this – the product might fail, or simply not fulfill the requirements set by the customer. Defects can cause claims, which causes extra processing and other costs, while also causing customer dissatisfaction. (Womack & Jones 2003; Hicks 2007; Hicks et al. 2006) Product usage and state producing IIOT applications can be used to product data of how the product was used before and at the moment it failed, as found in chapter three. This knowledge can be used to find situations in which the products tend to fail and gain of understanding of why they do. (Porter & Heppelmann 2014) Combined with better understanding of customer groups, the products can be targeted to environments that suit them, or the problems can be addressed by product development.

Thus, we end up with four main waste targets for product management. As found in chapter 3, all the applications evaluated in this work either produce new information, or at least make information flow easier or more efficiently. The two information management waste types of these types are failure demand and flawed flow, making them obviously important for IIOT applications. From manufacturing waste categories extra processing can be reduced due to better understanding of product requirements and users, and defects can be reduced with the understanding of product failures and by better sales targeting. In table 5 you can find the waste types and different applications that reduce the type of waste.

Table 5 IIOT Applications and Affected Waste Categories

IIOT Application	Information gained	Waste category affected by application
Market/customer segmentation	Customer needs and usage patterns in different market/customer groups	Extra processing Failure demand Flawed flow
Analysing usage for product planning and design	How the current product can be improved, are the products used like intended, is there waste	Defects Failure demand Extra processing Flawed flow
Creating sales opportunities	Marketing target groups	Defects Failure demand Flawed flow
Validating warranty claims	Are the warranty claims valid, how to spot invalid cases	Failure demand Flawed flow
Analysing product faults	Why do products fail, are there patterns in how products fail	Extra processing Defects Failure demand

		Flawed flow
Creating new strategies and predictions	Product usage insights, trends and patterns	Failure demand Flawed flow
Communication of product value to customers	Sales arguments like product performance differences, value of the differences	Failure demand Flawed flow

4.2 Challenges and Prerequisites Defining the Costs of Industrial Internet Utilisation

The fourth research question of the study is what are the requirements to get the benefits of different IIOT applications. Prerequisites are things that need to be fulfilled to take advantage of an application. For example, as found in chapter 3.1, IIOT applications require data collection, communication and analytics to work. Prerequisites and the cost of fulfilling them acts as barriers of entry to the business. This question, and thus the prerequisites of an application are important to understand, as they will define the investment and costs of implementing an application, which then are needed to evaluate the feasibility of an application.

Several types of prerequisites can be identified for the utilisation of Industrial Internet. For this work I have identified three categories for the prerequisites – data related prerequisites, organisational prerequisites and technological prerequisites. In addition to these three categories there are other issues that need to be considered: it is important, that the application fits into an organisations strategy and product portfolio. (Raynor & Cotteleer, 2015) It is also impossible to implement an application unless there is enough money to invest into it. Investment can also be difficult to secure when value of the applications is difficult to measure, which Geissbauer et al. (2014) at pwc found was the most common challenge for IIOT implementation. While these kinds of prerequisites are important and need to be though about when evaluating the business case, they will not be studied more in this work.

IIOT applications are very data centered, since the value comes from the data. As such data quality, and what data is chosen and gathered is extremely important. Data quality has been defined as "measure of agreement between the data views presented by an information system and that same data in the real world" (Orr, 1998). Data quality is important for any information system or analysis and Industrial Internet is no exception. Industrial Internet systems often generate large amounts of data, which can make meeting the quality and technological requirements challenging. (Noronha et al., 2014)

The dimensions of data quality vary depending on the research, but for example the following can be used: accuracy, completeness, consistency and timeliness. (Storey et al. 2012) The data quality requirements of applications should be studied beforehand to avoid extra processing. It can also be difficult to make large changes to data generated by

devices after they have been fielded. The applications have three types of data sources to be considered: device data, external data and business systems data. For the IIOT applications, the data quality of each needs to be considered. (Porter & Heppelmann, 2014) Data quality decisions also effect technology costs: the more granular data required, the higher the communication, storage and analysis costs will be. (Noronha et al., 2014) In addition to technological costs, data quality decision affect organisational costs and requirements, as data quality of business systems is unlikely to change without organisational changes. According to Storey et al. (2012), an organisational data quality program, including clear ownership of data, and data quality on policy trainings are often needed to improve data quality.

According to Dobson and Strens (1994) organisational prerequisites in information technology are the prerequisites that come from putting a system in a social context. For example, values and ethics, power structures, obligations and responsibilities, and control and authority can create such prerequisites. These types of prerequisites often get ignored when designing a system and are often the source of difficulties behind implementation. Possible tools for estimating and mapping gaps in organisational model and processes, and thus costs, for information systems, include enterprise architectural models, like the model presented by Zachman, or the ORDIT model by Dobson and Strens (1994).

A large portion of costs and prerequisites come from building or acquiring the technology needed. Porter and Heppelmann's (2014) technology stack explored in chapter three provides a basis to evaluate what is needed. The three main parts of an IIOT system are intelligent product, communication, and product cloud.

The product itself might require changes to enable IIOT applications. The required components and their quality varies from device and application to another, but in general, sensors, communication, memory for short time data storage and processing power is needed, as well as suitable software. For communication layer suitable networking hardware, protocols and tools need to be chosen and built. Building the product cloud requires building at least asset management with capability of fetching data from the devices, data lake, and analytics and visualisation capabilities. All the layers require both software development and infrastructure components, as described in chapter 3.1. (Porter & Heppelmann, 2014)

The data requirements from other information systems and data sources also add technological prerequisites, as integrations need to be made to make the data available in appropriate format. According to the technology stack, the data needs to be brought into the same data lake with the device data. Customer segmentation, for example, requires customer information from different business systems, like customer management system. (Porter & Heppelmann, 2014) The technology stack requirements were studied in chapter 3.1 in more detail.

In addition to data and organisational prerequisites, and creation of technology stack causing costs, the usual cost structure of creating new software systems should be considered. These costs tend to include thing such as:

- Project management
- Requirement definitions from infrastructure, software and business process point of views
- Design, including drawings, software modeling and business process modeling
- Development
- Implementation, including setup, infrastructure and software installations
- Integration and testing, including infrastructure and software testing and training

These costs can be estimated by using for example Work Breakdown Structure, or other similar method. (Sequeira & Lopes, 2015)

4.3   Estimating Feasibility

In the previous chapters the different benefits and prerequisites of have been studied. To asses if implementing an application is feasible or not, both the prerequisites, i.e. the cost of implementation, and the benefits gained from the application need to be considered.

Estimating the value of flawed flow and failure demand can be difficult. The benefit gained is often better information for decision making, which can be difficult to calculate beforehand. Failure demand is easier to estimate. As found in previous chapter, it is the amount of resources used to gather missing or lacking information. This means that its maximum value is the cost of gathering that information with the old method. In practice the new application will also cost something to use, so the new costs will reduce the benefit.

Flawed flow is more difficult to estimate, since it is the cost of decisions made due to imperfect, erroneous, or missing information. Since the flawed flow reducing applications are used to generate new, more accurate information to help with decision making, the value of information (VoI) from decision theory could be used to estimate value. The value of information means the maximum amount of money a decision maker would be willing to give to get the information for a decision. (Howard 1966) If the investment needed is less than the price of information, the application is feasible.

While it is easy to count in specific cases where the effect of the information is known, this is not always true for applications based on the Industrial Internet. In information value theory the value of information is calculated from the expected monetary value of the decision with and without the information. (Hubbard 2007) Another term used is the value of perfect information, which means the value perfect information of the situation would have. Using value of perfect information, it is possible to deduct the value added

by new information, by comparing it to the old situation. See Hubbard (2007) for the process of calculating the value of information.

One of the most commonly used metrics in management accounting is return on investment (ROI). Return on investment tells how profitable an investment is. It is calculated from the gain and cost of an investment with the following formula:

ROI = (Gain from Investment – Cost of Investment)/(Cost of Investment)

If information is the benefit of an Industrial Internet application, its expected value can be used as the gain from investment for the profitability calculation purposes. To be able to calculate the return on investment the cost of investment is also needed. The different technological, organisational and data prerequisites can be used to decide what actions and resources are needed to realise the benefits of an application. Together with project and planning related work these can be used to evaluate the costs, as found in chapter 4.2. Likely, the same technology stack used for product management application purposes will benefit other areas and applications as well, so the costs should be divided between different them. By using the cost of those actions and resources as the cost of investment and the expected value of information as the gain from investment its return on investment can be calculated as follows:

ROI = (Waste reduction - Cost of Investment)/(Cost of Investment)

Where waste reduction for flawed flow could be calculated using the value of information, and otherwise evaluated from current cost structure.

Industrial Internet applications, as found in chapter 3.1, can reduce manufacturing type waste and/or information management type waste. The value of the reduced waste is the main benefit of the application. As such it can be as the gain from investment in profitability calculations. The applications often affect several waste types, in these cases the gain from investment is simply the sum of all the waste reduced with the application, be it manufacturing or information management waste.

5. RESEARCH METHODOLOGY

The style of the study was quite explorative. New potential IIOT applications were studied, built and evaluated for the study. The main research tools used were literature review, interviews and case studies. The study was done inside one company, though interviews are from several organisations within the company. Due to its explorative nature, the research was mostly qualitative.

The study started with a preliminary round of interviews to find out possible interesting areas, leading to research of the areas and a second round of interviews based on the preliminary round. After that round of interviews applications were built for case studies. Those applications and their usefulness were then evaluated in the last round of interviews. The overall study process is described in figure 5 below.
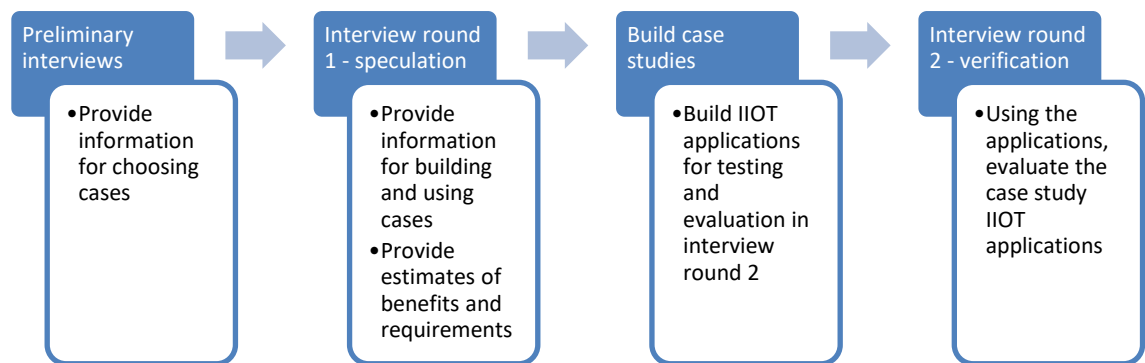
Preliminary interviews		Interview round 1 - speculation		Build case studies		Interview round 2 - verification
•Provide information for choosing cases	→	•Provide information for building and using cases •Provide estimates of benefits and requirements	→	•Build IIOT applications for testing and evaluation in interview round 2	→	•Using the applications, evaluate the case study IIOT applications

Figure 4 Research process

5.1 Interviews

Several interviews were conducted to gather data for the case studies. There were three rounds of interviews and a total of eight people were interviewed. The people interviewed were part of different product management departments of the company. The interview process and expected results are described in figure 6 below.
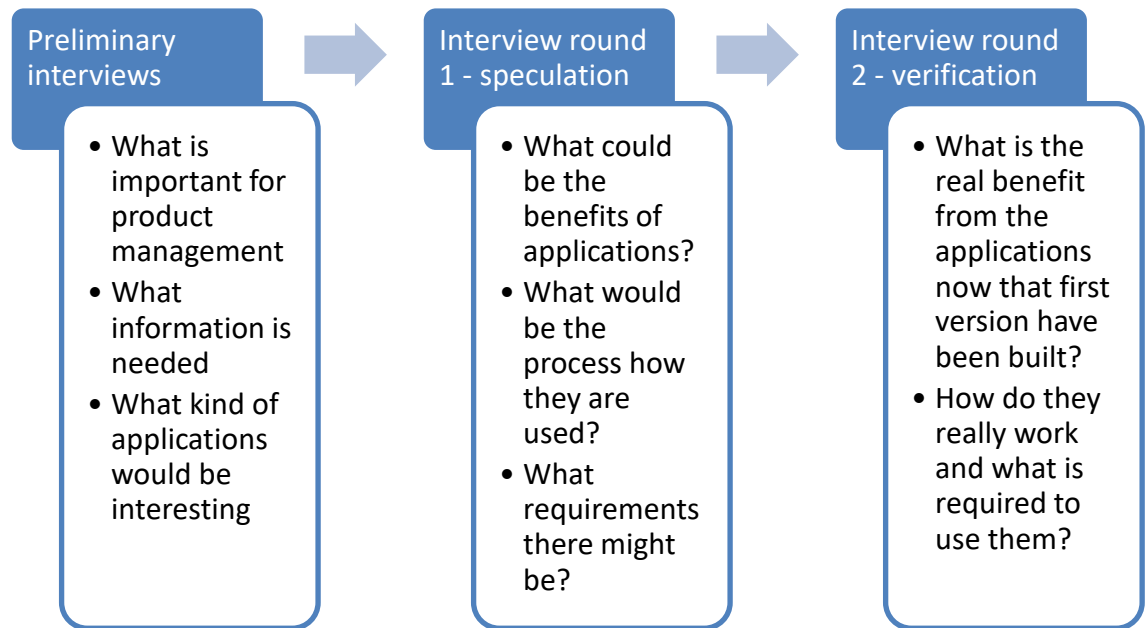
Preliminary interviews		Interview round 1 - speculation		Interview round 2 - verification
• What is important for product management • What information is needed • What kind of applications would be interesting	→	• What could be the benefits of applications? • What would be the process how they are used? • What requirements there might be?	→	• What is the real benefit from the applications now that first version have been built? • How do they really work and what is required to use them?

Figure 5 Interview expectations

The purpose of the preliminary interviews was different from the last two: their purpose was to find out what kind of application people in the company thought were possible, what would be important in them and if they thought lean wastes is suitable for estimating the benefits. These preliminary interviews were conducted as semi-unstructured interviews to bring ideas and thoughts to affect the work.

First round of interviews was conducted in early 2016 and second round in April 2016. The first and second rounds both have the same set of questions, that can be found from appendix A. The purpose of the first round of interviews was to gather what benefits the interviewees thought would be possible to achieve and how they could be achieved. The processes, benefits, and value creation mechanism of the cases are based on the first round of interviews, and were then revisited and modified based on second round of interviews.

The first round of interviews started with introduction to what was being done and what the target was. After that the product management needs were discussed. Then I introduced the lean waste categories and value, shortly discussed them and their usefulness and asked if there were any unclarities about them. After that I went through the possible applications and their objective one by one. With each application the possible value creation mechanisms were discussed, as well as what the interviewees thought the benefits, using the lean wastes and value, would be, and what the prerequisites would be.

Second round interviews was conducted after the analyses were made. Their purpose was to verify the first round's results and study if the benefits could actually be realised from the analyses. The case study applications were done in between the interview rounds. This enabled answers based on more than speculation, helping build a more realistic case of

the usage with the interviews. Also, having the two rounds of interviews were interesting in that, they showed some differences between expectations and reality.

The second round of interviews proceeded in much the same way as the first. I went through the lean waste categories and value, and discussed them with the interviewees. After that I went through the built applications, how they are used and why. After that the benefits and value creation mechanisms of the applications were discussed.

Interviewees for the round are in table 6 below.

Table 6 Interviews

	Preliminary interviews	Interview round 1-speculation	Interview round 2 - verification
Number of interviews	3	6	6
Interviewee organisations	Product management and development	Product management and development, Brand product mangement	Product management and development, Brand product mangement
Interviewee job titles	Vice President, Product management and development, Product Manager	Director, Product management Product manager, Product engineer	Product manager, Product engineer

One of the product managers worked as a primary target for the applications and owned the products used to get the data. One of the interviews in second round was with two product managers present at the same time. The interviewees from rounds one and two were the same with one exception.

5.2   Case Studies

The case studies used in the work involved creating Industrial Internet applications and testing them in the company environment. Their role was to provide a means to test building and using them, getting a concrete way to see how they can be made to work and how benefits can be gotten from them. In this role, they provided a good basis to use with the second round of interviews for interviewees to evaluate the benefits.

While there were several possible applications to study, three of them were chosen for this work. These are:

1. Customer segmentation
2. Product fault analysis
3. Sales support

There were several reasons why these case studies were chosen. First reason is that according to learnings and results from theory they answer to different problems of product management, which helps to testing in as wide area as possible. Second reason is, that each of them was seen as potentially quite valuable and they came up in the preliminary interviews as interesting applications, which also seemed possible to realise. With the exception of customer segmentation, the case names are different compared to theory. This is partly because each of the cases has two to three theory applications under them, because it made technically sense to build them into bigger entities.

All the cases were built using the same technology stack, that included smart devices with several sensors and information about their usage and condition. The data from the devices was communicated to the company's product cloud, which included storage for the data. All the cases required some other information as well, including product meta data, customer data, claim data and so on. The data was combined, analysed, and visualised using the SAS technology stack.

There were several hundreds of millions of lines of usage data available for the devices. Several models of devices were also available. The device fleet analysed consisted of thousands of devices. The applications also required data from additional systems. The data quality between the systems varied, which made the analysis difficult at some places. The data quality problem of some data was also an issue with the quality of some parts of the applications, thus likely affecting the end results of the application somewhat.

First case study is customer segmentation. The case was chosen due to interest in it based on learnings from theory and preliminary interviews, and due to it being useful for the other applications. The case was split into two different ways of utilizing the segmentation: validation and opportunity exploration. It was mainly used for portfolio management, even though other types of usage were seen as well. The application is described in more detail in the results chapter. The customer segmentation application built was mainly used by the primary interviewee. The rest were shown the application and had time to try it before the second round of interviews, though some had not had the time to do so. For this reason, the accuracy of the answers varied, and more weight were given to the answers of the primary interviewee.

Second case is product fault analysis. The case was partly chosen due to interest based on literature, but there was also an ongoing project on product quality, which made the information potentially interesting for the company. The information was not used for that purpose at least during the study period, but other uses were found as seen in results chapter. Some of the data from business systems was problematic with this case.

Third case was sales support. It also seemed interesting from literature point of view and was found to be interesting in preliminary interviews. Also, there were sales cases

open during the study period were the information could be used, leading to the applications being used in real situation as well.

6. RESULTS

The main research question of this work was to find how IIOT applications can be used in the product management of a metal industry company. In the previous chapters I have studied the theory of product management, and Industrial Internet and its uses and benefits in product management. As described in chapter five, the case studies included test applications that were used together with two rounds of interviews to find out in practice how the applications can be used and what their benefits in real life are. The purpose of this chapter is to present the results of interviews and test applications. Three case studies were chosen for this work.

First part of the work was to find out what kind of applications the company thought was possible and interesting. The following applications were found in the preliminary interviews:

- portfolio management by product use based customer segmentation
- analysing product faults and claims
- analysing product misusage
- sales arguments
- customer insight
- brand building
- Accident monitoring and emergency response coordination

The first case to be studied is using usage based customer segmentation for portfolio management, the second one is product faults analysis and the last one is sales support. The structure of each subchapter is the same. I will first briefly study the purpose of each application. After that I will explain what kind of process was found for the application, how the analysis was made and what benefits were found.

6.1 Preliminary Interviews findings

The preliminary interviews were conducted to provide information to support choosing the cases, understand the needs better and test if lean wastes and value seemed like a good way of estimating the benefits.

The organisation and role of product managers was also discussed in the interviews. The company had different product management organisations for brand and components product managements. Due to confidentiality the exact answers cannot be reported, but the objectives were similar to those of Chunawalla. Based on the interviews a figure with responsibilities, information needs and flow between product management and other organisations was drafted.

According to the interviewees, using lean wastes and lean value were useful for estimating the benefits of applications. One interviewee mentioned that "These (wastes and value) need to be used for this."

Calculating value of information for flawed flow also seemed possible to do at least in this context and company, since the estimated impacts of decisions were often available through business cases. The same product manager who mentioned that also thought, that using the lean wastes and value of information would be good way of estimating past decisions.

It was also thought, that having the same data from competitors would have been very valuable, but probably quite difficult to get. Overall, the most challenging thing for product management, according to the interviews, seemed to be gaining all the different information needed for the analyses.

6.2   Case 1: Customer Segmentation by Product Usage

Customer segmentation by product was one of the potential applications found in chapter three of this work. Both two basic ways of creating customer segmentation were combined to grant a good view of the segments. Segmentation was done both from usage point of view and from industry point of view. In the case study the segmentation was mostly used for portfolio management. The case was chosen because many other cases build on customer segmentation, and the benefits seemed high based on the literature review.

6.2.1   Case 1: Customer Segmentation Process

In the interviews two main ways of benefiting from usage based Customer segmentation was found:

1. Validating products or product features based on usage data
2. Exploring new business opportunities.

The purpose of validation is to find out if current design and marketing choices are valid. This was done by comparing design and assumed values to those of the real system, as shown in figure 7. An example of this could be, that a product is designed for really heavy usage. Testing if the real usage is actually that heavy grants insight in whether the design choice was good or not. This information was found to be useful when considering new products, but it was also found, that evaluating past decisions could be useful.

Purpose of new business exploration is to find needs that are not currently fulfilled. For example, finding a specific kind of product usage that is not addressed by the current product portfolio was considered possible.
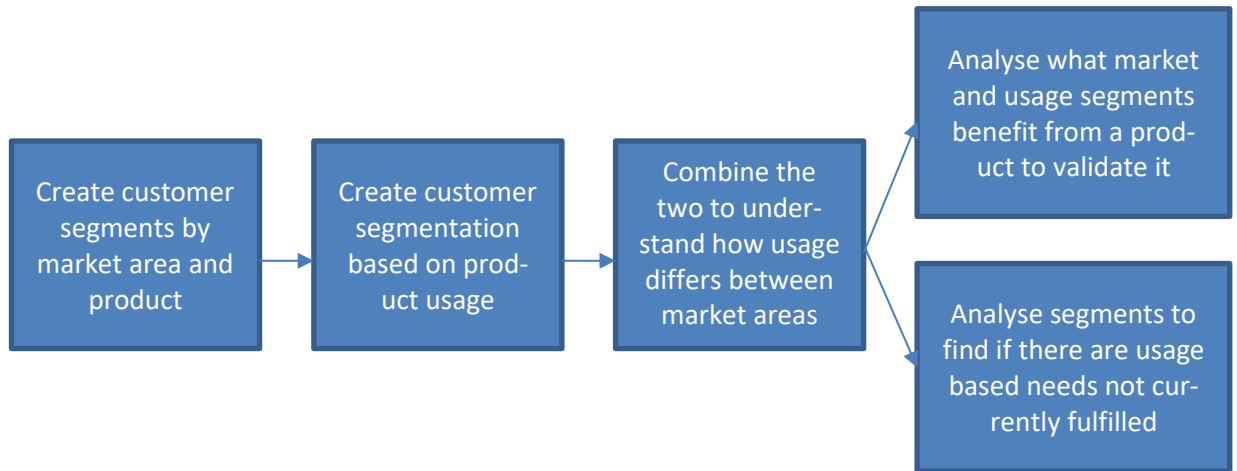
Figure 6 Customer segmentation process

The first three steps in the process are creating a customer segmentation suitable for portfolio management. The last steps create knowledge on how well the portfolio serves the current needs of different customer segments and how more customer value could possibly be created. Figure 8 shows part of the dashboard used for the customer segmentation process. Data was collected from several systems to produce the dashboard. The overall process of creating the dashboard was quite similar to that found in chapter 3 for creating Industrial Internet applications.
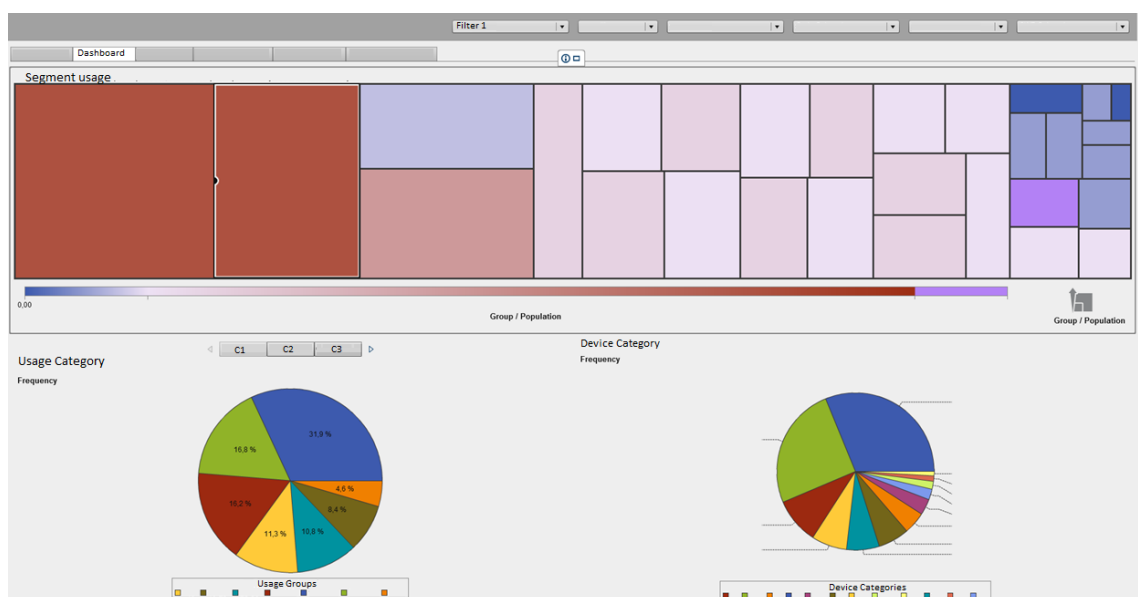

Figure 7 Customer segmentation dashboard

Segmentation was done by device usage values that best described how heavy and frequent the devices usage is. The value limits of the segments were chosen by limits that were interesting for business purposes, and also in some cases too small segments were combined. Since the purpose was not to work as an outlier analysis, the devices that were much too far off were also removed.

The segmentation dashboard consists of a large treemap and two pie charts. Each "box" in the treemap represents an industry. The box's colour and size tell in how heavy usage the median product in the segment is. The segments in the treemap are hierarchical to allow drilling deeper into the industries to compare different companies and production sites. The pie charts below tell how large number of products belong to a certain usage groups. Selecting an industry segment filters both of the pie charts, allowing the user to examine an industry in more detail. Another similar dashboard was made from usage point of view, letting the user view the data from another angle. Once the dashboard is made and updates to new usage data, only the last part of the process needs to be practiced.

6.2.2 Case 1: Benefits of the Application

Customer segmentation in this case was mainly used for portfolio management purposes, though other uses were also discussed, while theory saw other use cases for market segmentation as well. Table 7 has the benefits found in literature and interviews.

Table 7 Market Segmentation Benefits

Application	Literature	First Interviews	Second Interviews
Validation	Extra processing Failure demand Flawed flow	Extra processing Failure demand Flawed flow	Extra processing Failure demand Flawed flow
Opportunity analysis		Value Failure demand Flawed flow	Was not realised during the study period

In first interviews the same potential benefits were found. The benefits in validation were mostly found to come from understanding if products are used in designed way and if the real usage benefit from a product feature or not. This way of thinking was mostly related to product planning, and finding out if design choices were good. Interviewees also though that the knowledge could be used for selling and marketing purposes. It would let the marketer or salesman understand the difference between customer segments and offer products better suited for them. Bit under half of the interviewees also thought that in this case new needs could not be found product usage, though the rest disagreed.

In terms of lean waste reducing, this could reduce extra processing since the amount of product features and choices could possibly be reduced. Failure demand and flawed flow

would be reduced since more detailed information would be easily available. Opportunity analysis was thought to be less likely to provide benefits than validation, which was seen as the primary way of using the analysis.

In the second interviews, after the analysis was made, it was found that the benefits from the first interviews could mostly be gained. There had not been time to use the analysis to try to find new opportunities, so that part of the work did not get a confirmation.

Case 1: Prerequisites of UtilisationData from several systems was required to build the segmentation dashboard. CRM and sales systems were needed for the industry and customer data, and product metadata and usage data were gathered from other systems. All the interviewees agreed, that data from the whole lifetime of a product would be useful, as it would make lifecycle management and quality management easier. Data is also needed from a large enough number of products to make the differences between the segments statistically reliable. This was challenging, especially when it came to customer segments only small number of customers.

To benefit from the analysis, it needs to be taken into product planning and other relevant processes. For example, when designing a new product, the usage based segmentation should be taken into account to better understand customer needs.

6.3   Case 2: Identifying Product Faults

Identifying product faults and validating warranty claims were chosen as the second case. They were combined, since it was possible to build one application to address both issues. In the end the application was not used for claims validation during the research period, so the results in that area stayed theoretical.

6.3.1   Case 2: Product Faults Analysis Process

The first interview round included unstructured discussion about application processes – how they should be used and what is needed. The interviewees thought that the claims validation process is quite simple. According to the discussions, when a new warranty claim is gotten, the usage history of that product could be checked for misusage. If the product had not been properly used, then the warranty claim might be invalid.

Fault analysis process was a bit more complicated, and required customer segmentation as well. The process is shown in figure 9. The first part of the application required creation of segmentation based on customer groups, product usage and product use case groups and analysing different types of product misusage and its likelihood in them. After this it was possible to pin down typical problems for different types of customers. For example, it was found, that certain customer types tend to buy a product that is not equipped to handle as heavy usage as was likely, which led to misusage of the product. The main use

case for the information was found to be sales, as they could affect what the customer buys, recommend a product that is likely more suitable and back the recommendation up with arguments based on usage data.
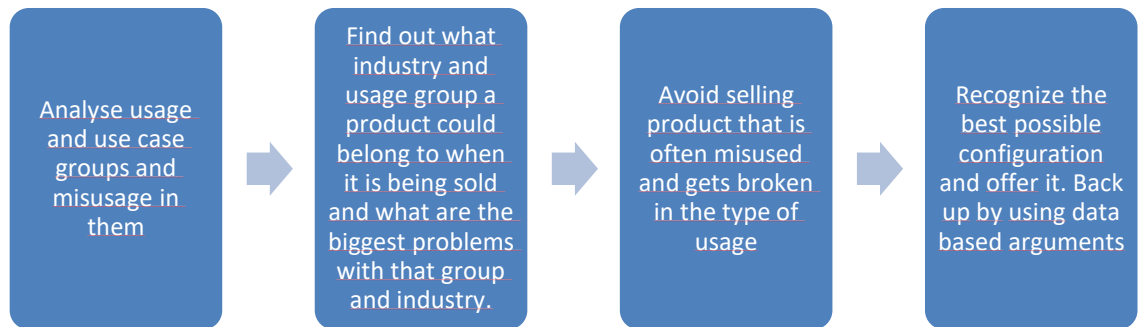

Figure 8 Product Fault Analysis Process

A couple of analyses had to be made for different types of misusage, and to combine them with segmentation shown in chapter 6.1. Figure 9 has part of a dashboard showing how common product faults for different product categories were and how often they were not used correctly.
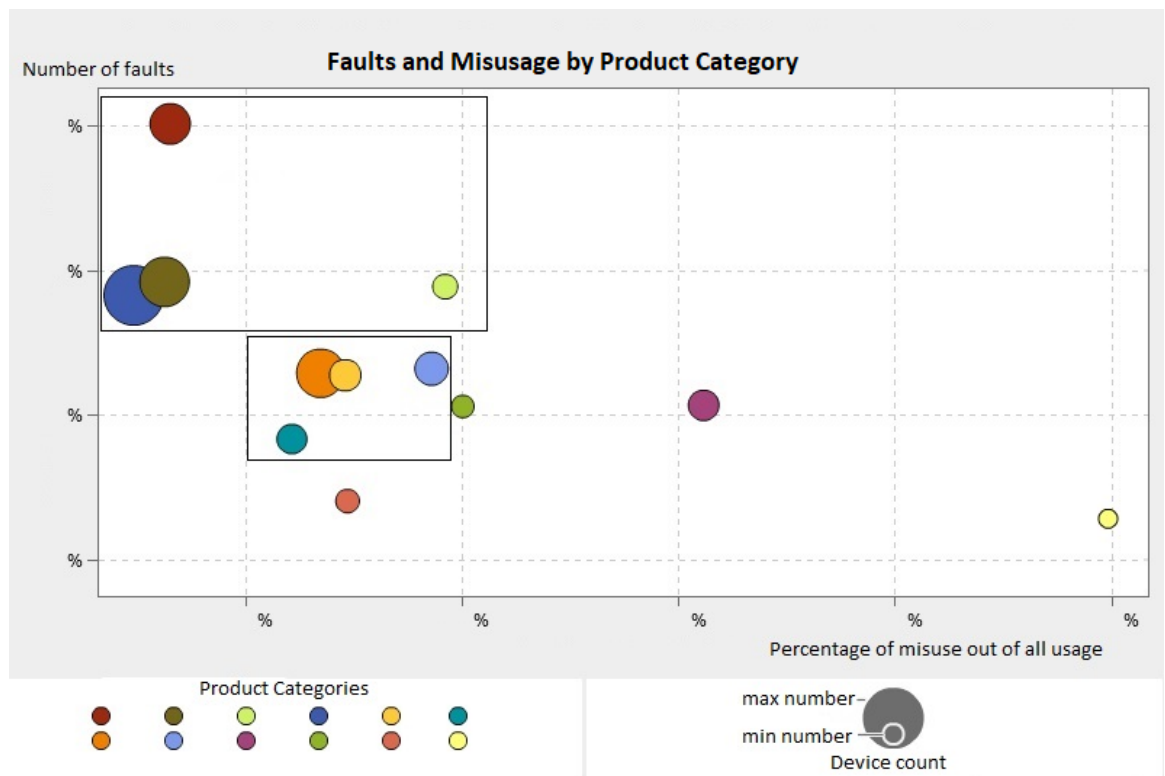

Figure 9 Product faults and misusage

Figure 10 below shows another example of misusage analysis, with different types of misusage per customer segments. There were some customer segments where it was apparent that to light weight products were often sold, which led to them being used in incorrect fashion. It came up in the interviews, that understanding of how different product groups used the products, combined with how often and in what way they were misused was important to get value out of the application.
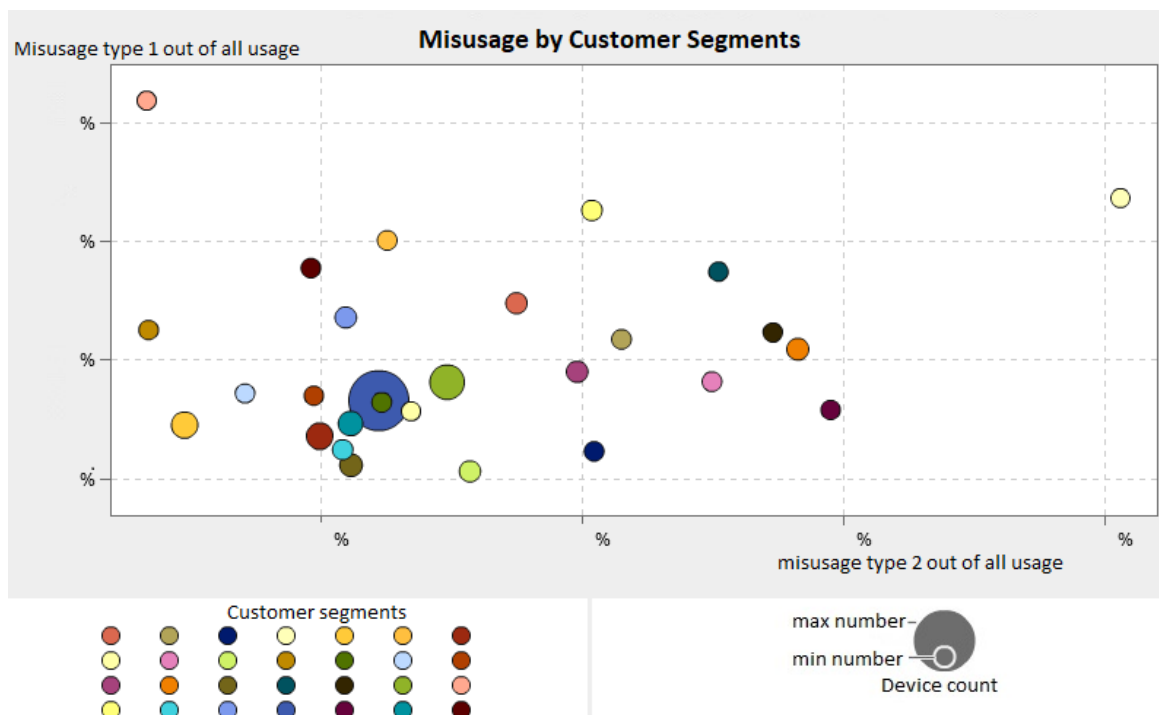

Figure 10 Misusage by Customer Segments

6.3.2 Case 2: Benefits of the Application

Table 8 holds the benefit types gained from the applications based on literature and the interviews. Second set of interviews was not done for claims analysis, as it was not used in practice during the evaluation period.

Table 8 Product Fault Analysis Benefits

Application	Literature	First Interview Results	Second Interview Results
Product fault analysis	Extra processing Defects Failure demand Flawed flow	Defects Failure demand Flawed flow	Failure demand Flawed flow
Claim validation	Failure demand	Failure demand	-

	Flawed flow	Flawed flow	

The benefits of product fault analysis were found to mostly come from being able to offer better suited products, which lowers claim costs and customer retention. For some products this information had not been available before IIOT applications, and for some collecting it had been costlier, as getting the data had meant visiting the site were the product was used. Due to industry standards it would have been difficult to affect extra processing, so that was not achieved. It was also difficult to show the difference in defects during the study period, so it is missing from the second set of interviews.

As mentioned, claim validation was not used in practice, though the data could have enabled it. The primary value gained from claim validation, according to the interviews, would have been the information of whether the claims were caused by improper use or not. This could have affected claim costs, by reducing the amount of time it takes to validate the case, and by finding more invalid warranty claims. The company knew that some portion of the claims were caused by misusage, but it had been difficult to show in practice. Also, the information might have been useful for product development to gain more insight on in what kind of situations the products break. One problem with using the information for claim validation was, that customers might have felt like the capabilities and data was used against them, which could have led to them disabling the IIOT services from the products.

6.3.3 Case 2: Prerequisites of Utilisation

The IIOT technology stack required for monitoring level applications is required to collect and analyse the data, but no unusual technical prerequisites were found. Since there was heavy usage of segmentation, that was also required, and thus the prerequisites of segmentation are also valid with this case.

The different types of data required included:

- Usage data
- Product faults
- Customer segmentation
- Product metadata
- Maintenance data
- Claim data for claim validation

Some of the data was from different systems, and the data quality was partly problematic. Fixing the data quality was found to require process changes in how different systems were used. From process point of view three additional new steps would have been required to gain full benefits:

- Using the information needs to be taken into sales process
- The data should be taken into account in product planning
- Product management should update guides as products and faults are analysed.

6.4   Case 3: Sales support

Several ways to support sales with IIOT based information was identified during the interviews. The three most important applications for this type of information for the interviewees were:

1. Creating usage based sales arguments
2. Customer insights in sales
3. Helping sales build brand value

The latter two mostly came up as use cases for the data, and also as byproducts of using the IIOT based arguments, as using measurement based arguments can make the company look more proficient according to one of the interviewees. From IIOT point of view however, the sales arguments were only one type of application.

6.4.1   Case 3: Sales Support Process

The interviewees recognised two processes of using IIOT based sales arguments. The processes were drafted in the first interview with a product manager, and then slightly changed based on comments from other interviewees and finally checked with the first interviewee again. Figures 12 and 14 describe a case were sales has need for certain type of sales arguments for a sales case, and figures 13 and 15 describe sales arguments process when creating new features or products.

Both processes are quite similar to each other, and also resemble the product fault analysis, which ended up mostly being used for sales arguments purposes. With sales arguments process the process starts with sales organisation requiring information to help with a sales case. In such cases the information seemed to be related to quite specific issues, like the usefulness of a feature in certain environment. The target feature, or product, could then be compared to the whole product fleet in similar environments to find correlations between feature and product life or value produced. These in turn could be turned into estimated value gained or money saved by taking the feature or product, giving sales a new tool for providing rational arguments.
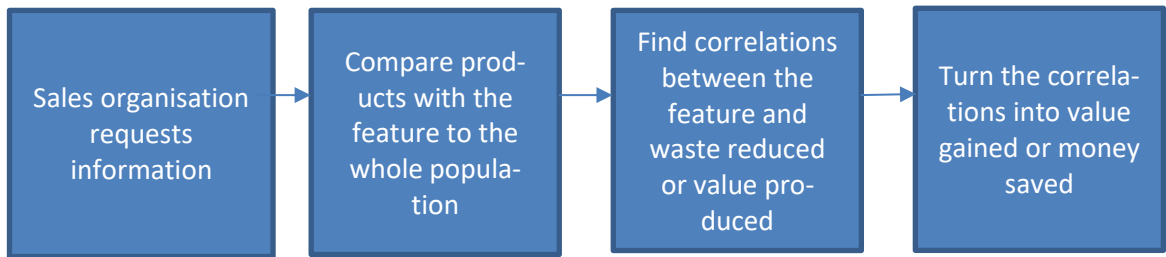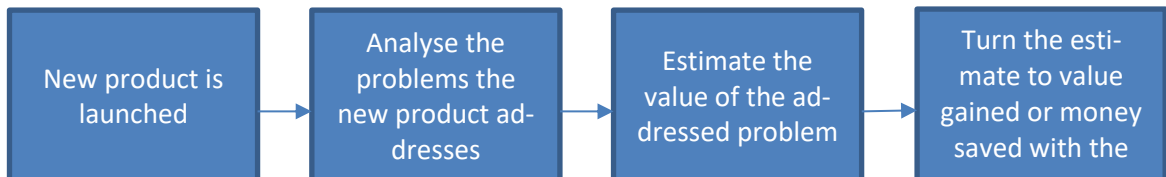
Figure 11 Sales argument process

Figure 12 New product sales argument process

Figure 14 below shows an example of how IIOT data was used as sales argument in an IIOT application created for the study. The purpose of the graph and its data was to help promote a more expensive feature. There are two feature options, with different prices. The choice of option affected the lifetime of the product, which was not found to be very significant in very low usage categories, but extended the lifetime significantly if the product was in heavier use. This data can be used to compare the additional value and savings gained to the pricing of the options.
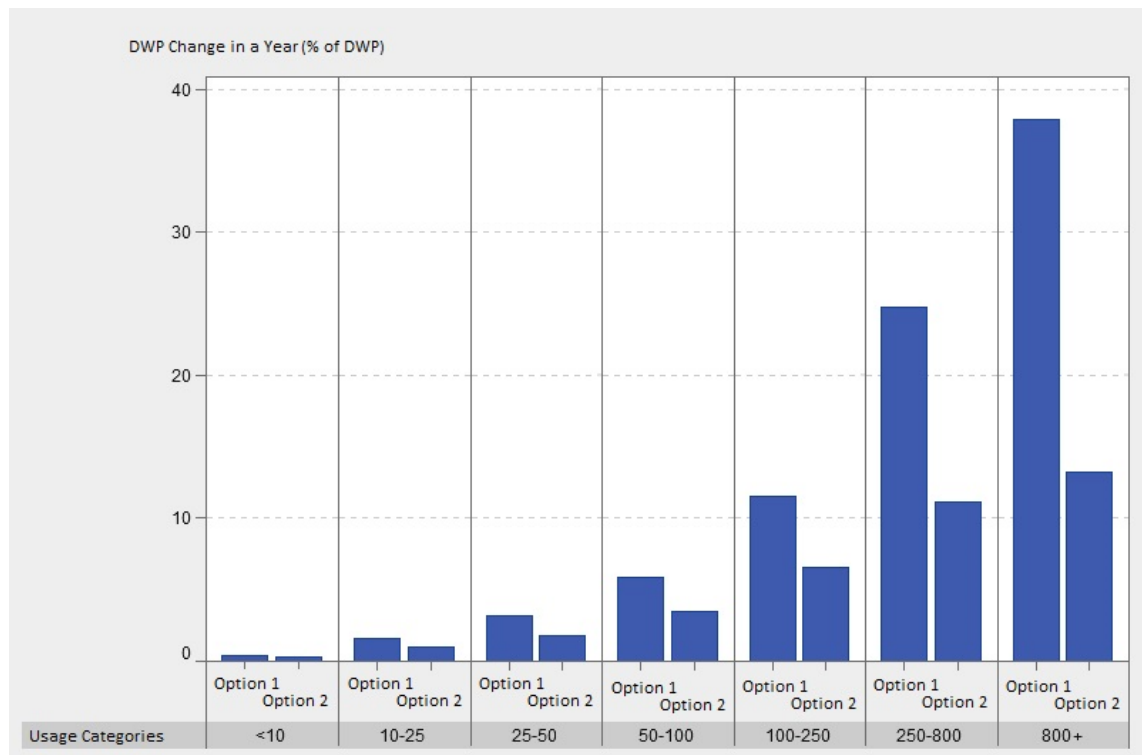

Figure 13 Sales arguments example 1

Figure 15 below describes product usage over two different dimensions. It is another analysis that was used as part of the study. The colour of the heatmap tells how often certain type certain type of usage has occurred in the past, while the attributes on x and y coordinates are usage parameters of the device. A new feature was able to make the usage more comfortable and efficient and make the product last longer, but prevented certain type of use. However, it was found using IIOT data, that this certain type of usage had never happened in real-life, making the trade-off very good. The area on the upper right corner would have been the area that would have been slowed down by the new feature. This information was useful for showing to customer, that the trade-off was not a problem.
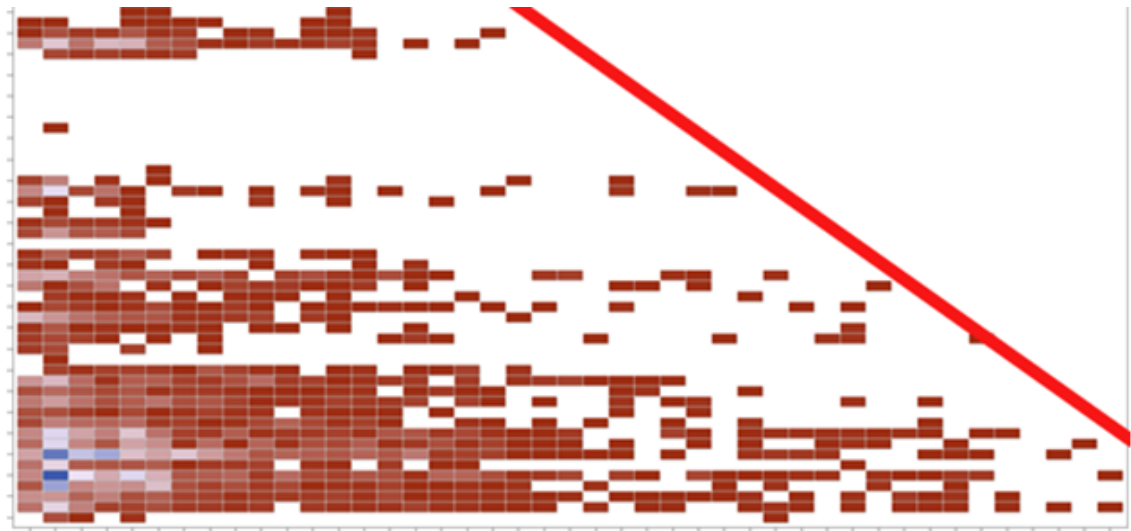

Figure 14 New feature sales argument example 2

It was also found in the interviews, that when existing customers buy new products, it might be possible to gain substantial benefit from analysing how that customer has previously used their products. In such cases it would likely have been very beneficial to ask if the new product was going to be used in similar way and choose the best possible product for that type of usage.

Also, building brand value with the applications came up in the interviews. The information provided was a good way to show differentiate from competitors, by being able to show that the company cares about their customers, and knows how different options affect product wear and usage. These two applications were not tested during the study period, however, but the latter one seemed like a by-product of using IIOT based information.

6.4.2   Case 3: Benefits

Table 9 below holds the benefit types of the application.

Table 9 Sales Support Benefits

Application	Literature	First Interviews	Second Interviews
Communication of product value to customers	Failure demand Flawed flow	Failure demand Flawed flow Value Defects	Failure demand Flawed flow

In the interviews it came up, that gathering this type of information had previously been very difficult and resource intensive, leading to often having to work without such information.

The interviewees also thought that the application might directly produce customer value, since the customer could gain useful information about product usage that helps them get more value out of the product. Also, being able to choose the correct product helps reduce the amount of defect waste, reducing that as well.

For the second round of interviews, it had not been possible to get clear answer about the application reducing defects and generating customer value, but generating the sales arguments was easier than before and new information was available. Even though it was not shown, it seemed likely, that customer value and defects reduction are still valid for the application, but the timeframe was not long enough to verify them.

6.4.3 Case 3: Prerequisites of Utilisation

The prerequisites seemed to fall mostly to the three categories found in theory. From technical point of view, the IIOT technology stack required for monitoring applications is required to gather the data. Also, CRM integration was deemed beneficial to make the information more readily available for sales people.

From data point of view, the application requires large enough data sets to make the results statistically meaningful. The types of data that was needed was:

- Product information and lists of products with certain features
- Usage data
- Product metadata
- Customer segmentation information

Maintenance history was also thought to be useful, so that costs could have been more directly calculated for the features and products.

From organisational point of view, sales organisation needs to change their processes to start requesting information from product management. Product management also did not have the analysis capability within it, which would be useful. When creating new products, fact based argument creation also needs to be part of the development process.

7. DISCUSSION AND CONCLUSIONS

The purpose of this chapter is to answer the research questions based on the theory and case studies presented before. In the discussion chapter I will go through the research questions one at a time, and then answer the primary research question in the conclusions chapter. After that I will conclude the work by evaluating the study and present possible future research topics.

7.1 Discussion

Q1. What are the needs in product management that can be answered with industrial internet applications?

In chapter two the different product management objectives were studied. According to Chunawalla (2009) These include

- Designing product strategies
- Sporting marketing opportunities and analysing if they are exploitable
- Seeking growth through new product development
- Planning strategies for different parts of product lifecycle
- Generating new product ideas and developing them
- Managing product portfolio
- Managing and building brand position, image and value.

In the preliminary interviews the responsibilities of product management in the company were also discussed. They were not exactly the same as in Chunawalla's (2009) work, due to slightly different organisational structure. One such difference was that the company had different product management for its brands and their products, and for the components the products used.

Fulfilling the objectives requires different types of information. It is especially important for a product manager to understand their customers, products, and how the products are used. Industrial Internet monitoring level applications can provide this type of information, which was previously missing or difficult to get.

It was found both in literature, and in interviews, that the information provided by IIOT applications can provide useful information to aid with all of the product management objectives. Thus, the answer to this research question is, that IIOT application can help answer all different product management applications by providing useful information with monitoring level applications.

Q2. What are the possible applications of industrial internet in the target organisation?

IIOT applications that might be interesting to product management were studied in chapter three. these applications were discussed in preliminary interviews in the target organisation. While all the applications seemed interesting, three cases were chosen:

1. Customer segmentation
2. Identifying product faults
3. Sales support

The applications are partly mixes of IIOT applications from theory chapter three, and product management or sales functions from chapter two. This brings the actual number of tested applications higher than the case number. Also, the split of customer segmentation into validation and opportunity analyses, and splitting of sales support into sales arguments for new and old products for communication of customer value had not been considered in literature. The way combining the applications due to technical reasons into three real applications was also interesting.

To answer the research question, all the different types of monitoring applications would have been interesting and possible in the target organisation, and three applications were built. Due to technical reason the applications built included more content than their theory variants, as described in the results section.

Q3. What are the benefits of those applications?

The benefits of the IIOT applications for product management come from the information they help product. Both the interviews and literature agree in that information having been difficult and costly to gather before IIOT applications. Missing this information caused waste

Table 10 Application benefits

Case Study	Application	Benefits from literature	Benefits from first Interviews	Benefits from second Interviews
Case 1	Validation	Extra processing Failure demand Flawed flow	Extra processing Failure demand Flawed flow	Extra processing Failure demand Flawed flow
	Opportunity analysis		Value Failure demand Flawed flow	Was not realised during the study period
Case 2	Product fault analysis	Extra processing Defects Failure demand Flawed flow	Defects Failure demand Flawed flow	Failure demand Flawed flow
	Claim validation	Failure demand Flawed flow	Failure demand Flawed flow	-

Case 3	Communica-tion of product value to cus-tomers	Failure demand Flawed flow	Failure demand Flawed flow Value Defects	Failure demand Flawed flow

In literature the benefits of segmentation come from reducing extra processing, failure and flawed flow. Extra processing is reduced by reducing product line length, while flawed flow is reduced by introducing a source of information that was previously not easily available. The knowledge created can answer to product management knowledge needs, thus reducing the amount of resources needed to gather similar data from else-where and the potential wrong decisions made due to lack of information. Opportunity analyses had similar potential. Both were also able to indirectly create customer value, since products can more easily be tailored to customers' needs.

This is partly misguiding however, since the benefits from literature and case were real-ised in somewhat different way. In the case study more of the benefit was seen to come from product planning. The same possible benefits were seen for it as seen in literature however.

In literature the benefits from product faults analysis seemed to come from being able to gain information more easily than before, or being able to gain new information that could be used to make better decisions. During the case study a difference could in extra pro-cessing could not be achieved due to industry specific regulations. While in the interviews it seemed possible to eventually reduce defects using this type of application, it did not materialize during the study. Claims validation was not used during the study period, so it is difficult to verify if the benefits could be realised. There were no difference in opinion about it between the interviews though.

Communication of product value proved interesting due to the easiness of generating in-formation that had been difficult to get before. Unlike literature, the interviewees also thought that the application might directly produce customer value, since the customer could gain useful information about product usage that helps them get more value out of the product. Also, being able to choose the correct product helps reduce the amount of defect waste, reducing that as well. During the study period the addition of value and reduction in defects was not possible to prove, due to the short time period of the study.

Q4. What are the prerequisites to realise the benefits?

Three types of prerequisites were studied. In chapter three Porter and Heppelmann's (2014) technology stack was studied to find the different technological needs and prereq-uisites for IIOT applications. It was apparent from theory point of view, that utilisation of any of the IIOT applications would require a working Industrial Internet technology

stack to gather and analyse the data. This could also be seen in practice, as creating any of the applications required all the basic technological components of IIOT.

Since, as found in chapter three, internal IIOT applications are very data centered, the availability and quality of data proved to be very important. With the technology stack in place, much of the time went to cleaning and combining data from different sources. Without good data quality, it is also difficult to build good IIOT monitoring applications. As such data related requirements need to be considered when building IIOT applications and also when evaluating the costs of building and maintaining them. Data quality of other sources need to also be considered.

Mainly due to the existence of a well-built technology stack, the biggest changes needed were those related to processes. To be useful, the information needs to be efficiently spread, requested and used. This flow of information also tends to cross organisation boundaries, making it challenging. Organisational prerequisites should thus not be forgotten when implementing new applications, just as literature in chapter four suggested.

Q5. How can the value of the benefits be evaluated?

Lean value and waste categories provide one tool for estimating the value and benefits of IIOT applications. The benefits of IIOT for product management come from the applications supporting product management functions and objectives. For this reason, the traditional lean manufacturing waste categories are not enough, but information management waste types need to be considered also. Put together, the different waste types and value created a framework which clearly helped evaluate the benefits of the case study applications both beforehand and afterwards.

Failure demand, flawed flow, defects and extra processing seemed to cover the efficiency increases well. In the interviews a product manager mentioned, that "non-optimal decisions are made all the time, leading to decisions being made without information, or it at least takes a lot of time to gather the information." He also said that "Extra processing and defects are something product management tries to actively effect all the time." It's possible that other benefit types are needed in different environments, but those categories worked well in the product management of the target company. Theory also supported using them.

Calculating the exact value would still be difficult, especially in the case of flawed flow, since monetizing information is difficult. For this, calculating the value of information could be used. The other types of wastes are easier to estimate. Overall, the waste categories provided a very useful tool for evaluating and categorizing the benefits, which also worked in practice.

7.2 Conclusions

With answers to the five research questions it is now possible to answer the main research question.

How should industrial internet be utilised in a metal industry company's product management?

Using the IIOT technology stack presented by Porter and Heppelmann (2014), it is possible to build monitoring level IIOT applications to generate information that is useful for product management. The information is useful, because it can fulfill product management information needs, especially when it comes to knowing and understanding customers and products. This in turn helps product management fulfill their goals more efficiently. The usefulness comes mainly from reducing flawed flow and failure demand waste types, but some applications decrease the amount of other waste types, mainly defects and extra processing, as well as customer value.

Lean wastes and lean value have the potential to work well, because they can translate the benefits gained from the information into something more concrete, making them easier to analyse and evaluate. Though difficult, it is also greatly helps monetize the benefits of the generated information.

The technical prerequisites for applications helping product management are the same as those of other areas benefitting from IIOT. Perhaps the only exception being that some additional data from business systems need to be integrated. This makes the applications very cost efficient especially when the technology stack is already in place due the capabilities being needed by other parts of the company.

Being relatively cost efficient and helping an important part of the organisation to create value more efficiently, building monitoring level applications for product management use seems quite lucrative.

7.3 Evaluation of Thesis

With the research questions answered, it is time to evaluate the thesis and its usefulness and validity.

Industrial Internet has been research a lot in recent years due to high demand in market. For some reason, the internal applications side and the value of the information it produces has not been well covered. Lean wastes have been used in many areas, including IIOT, but the information waste categories seem underused, especially since they could provide a valuable tool for estimating and understanding the benefits.

The subject was relatively challenging due to the complexity of applications and there not being a model in literature for combining product management needs to industrial internet applications. Even material about evaluation of the internal applications seems to be very scarce. Combining the three by using lean information management and manufacturing categories to evaluate benefits of IIOT applications in product management is likely new area. The results seemed encouraging, and the combination of information management and manufacturing categories would likely work very well with any IIOT application, due to how well they describe different types of information related benefits.

There were some potential issues that could affect the validity and need to be mentioned. First of all, the study was done in relatively short time and with very short use period of the use cases. This probably reduced the accuracy of the evaluations. Additionally, the approach of the interviewer presenting the applications probably risked the interviewer affecting the thoughts of the interviewees somewhat, but this was necessary due to the short time period and many interviewees not having really used the applications. Even so, getting evaluations of real life internal IIOT applications is interesting and seemed to mostly be absent in literature.

While the study period was somewhat short, the writing of thesis took long. This might have also affected the quality of the analysis. In some respects, it might have been good, because the evaluation was likely more objective than it would have been with everything fresh in mind. On the other hand, some context was likely lost due to the gap between study and writing.

Some parts of the literature review also depend on relatively few sources. Especially product management objectives and responsibilities are mostly based on Chunawalla's (2009) work. On the other hand, several sources seemed to acknowledge similar responsibilities, and the preliminary interviews also brought forth similar needs. If a company using this research had vastly different product management, some parts of the study might not be valid. Even then, many things, like the value of using lean wastes and value would remain just as useful.

Overall, I think the areas researched are very relevant and have not been studied enough. The approach was good, and the tools and infrastructure available were suitable for the study. The results and conclusions, even if possibly slightly skewed due to the issues mentioned above, seem like they would be useful in many different areas. The possible problems were likely also not large enough to affect the conclusions.

7.4   Limitations and Future Research

There were some limitations in the work. The most important of these were the length of the study period, and the cases being from a single company. The length of study period limited the accuracy with what the benefits could be evaluated, especially since many

planning related results take time to materialize. Being from a single company, it is difficult to also say the results are valid in general. For this reason, research covering several companies would be useful.

The technology stack was also in place already, which somewhat limited the data available from the devices. This was not a large limitation, as a wide range of data was available, but it did make analysing usage patterns difficult, for example. Overall the technology stack was well built.

Future research in the area would be valuable. Using IIOT data for internal applications seems to not be very well covered. Lean wastes give a good model for evaluation, but research from several companies and during a longer time scale would grant more complete and accurate results, which could lead to more companies adopting internal usage of IIOT data.

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APPENDIX A: INTERVIEW QUESTIONS

Preliminary Questions:

Investment related questions

1. What information do you need when making decisions on new IoT investments?
2. Could lean waste categories be used to estimate the internal benefits of different applications?
3. Do you think that ROI should be calculated for IoT investments?
4. Do you think that ROI calculated by using lean waste categories to estimate benefits is accurate enough?

Product Management

1. What are the functions of product management, what value do they create?
2. What kind of product usage information or knowledge could be useful that isn't currently available?
3. What types of waste do you see as a problem in product management? Which ones do you think could be reduced with IoT applications?

Rounds one and two Questions:

Benefit related questions

For each application:

1. Which of the waste categories do you think could be reduced with the application? Why and how?
2. How should using the application from process point of view work, what's the mechanism behind creating the value or reducing the waste?
3. What benefits in product management can you see for them?
4. What kind of business prerequisites can you see for them?