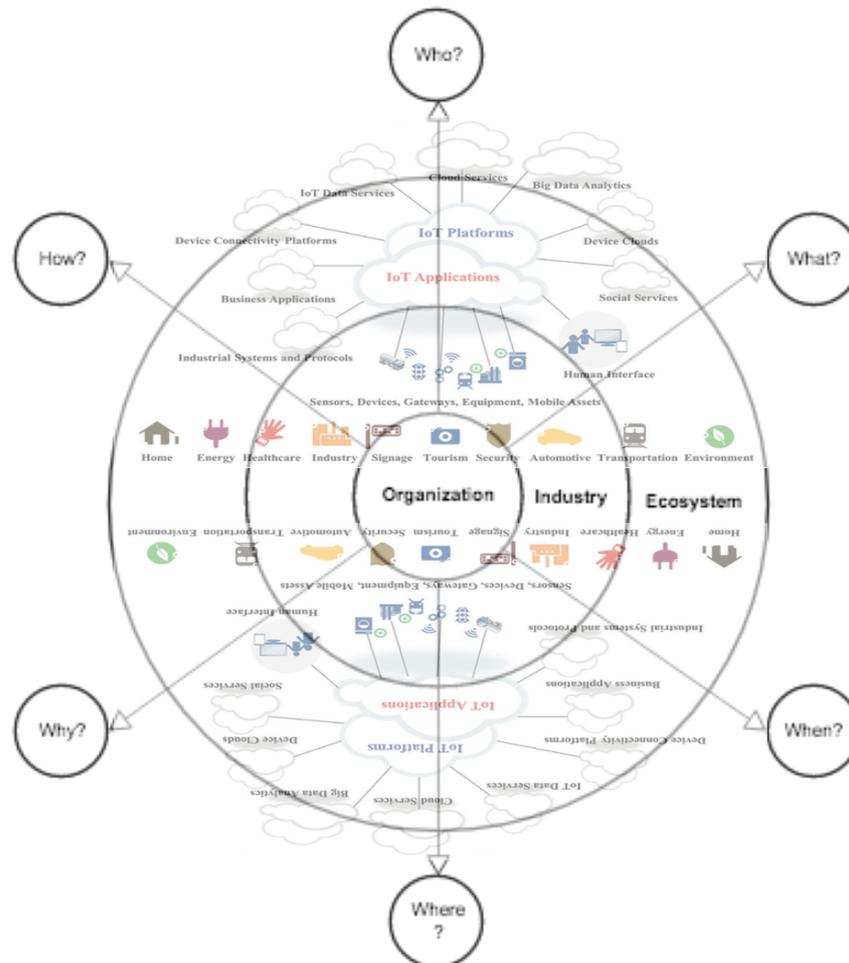


# Business Model Framework Proposal for Internet of Things

A theoretical research paper on Internet of Things  
from a business perspective



Danish title:

**En forretningsmodel rammeværk for Internet of Things**

En teoretisk forsknings på Internet of Things fra et forretningsmæssig perspektiv

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# Abstract

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The thesis focuses on researching the Internet of Things (IoT) from a business perspective. The initial research stage pinpointed a gap in research in this area, especially surrounding the concept of IoT business models. Much theory surrounding the subject highlights the need to research possible IoT business model frameworks, as traditional business model theory falls short of incorporating the complexity of the synergies and dynamics within an IoT ecosystem. In the initial literature search, only three relevant frameworks contributed to the concept of creating and evolving a business model framework, which support the IoT concept, namely Sun et al.'s (2012) "*A holistic approach to visualizing business models for the internet of things*", Turber et al.'s (2014) article "*Designing Business Models in the Era of Internet of Things – Towards a Reference Framework*", and Westerlund et al.'s (2014) article "*Designing Business Models for the Internet of Things*". However, after researching the concept of IoT from a business perspective in-depth, I identified some important criteria's which the previous mentioned IoT business models failed to incorporate, which included the complexity of the overall IoT value chain; the organization, industry and ecosystem, as well as different stages of the ecosystem, due to the instability of the highly innovative environment and the adoption to this.

To incorporate all these aspects, I therefore developed an IoT business model framework, based on the dynamics and complexity of the IoT concept, which incorporates the ecosystem synergies, stages, and business strategies and provides companies with a flexible approach that takes all essential aspects of the IoT concept into perspective. The IoT business model framework is built around the IoT value chain, which includes the organization itself, the industry it is part of, and the ecosystem(s) the organization becomes a part of when incorporating an IoT business strategy. The framework furthermore seeks to clarify all value creation and capture activities and flows, but also the challenges and barriers associated with these, by clarifying the "Who?" "What?" "When?" "Where?" "Why?" and "How?". But identifying all these aspects throughout the IoT value chain the model creates a sound foundation for a company to be able to understand, analyze, communicate, and manage strategic-orientated choices surrounding the IoT concept, and throughout the ecosystem. Though the model provides an extensive overview over these essential components, the model can also be formed to only highlight the components essential to the individual company, as it offers great flexibility, which is highly valuable in the fast evolving, dynamic and innovative IoT phenomenon.

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Through the hardship and doubt there have been, it is a time I would not chose to be without, as I have been privilege to get the opportunity to spend the last six months studying a highly relevant and exciting topic, which in turn have giving me great insight into the future possibilities this phenomenon brings.

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# Chapter 1 - Introduction

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*“It is not the strongest  
or the most intelligent who will survive  
but those who can best manage change.”*  
- Charles Darwin

## 1.1 Background

In connection with my Master of Science study at CBS and work at Microsoft I have with great interest followed the development of Internet of Things (IoT). It was first in 2012-2013 that the concept of IoT truly came on the agenda in IT courses and organizations, even though the phrase Internet of Things was already coined in 1999 by Kevin Ashton of Procter & Gamble, and the very concept have been around for much longer.

According to Gartner’s Hype cycle in 2014 IoT was the most hyped technology, where IoT was at the top of the hype cycle. Gartner’s analysts thought that the IoT had more than 10 years to reach the “plateau of productivity” in 2012 and 2013. But in 2014 the analyst gave IoT five to ten years to reach this final stage of maturity, and they say it is becoming a vibrant part of customers’ and partners’ business and IT landscape (Press, 2014). Furthermore, when Gartner presented their 2015 top 10 strategic technology trends on October 2014, IoT was on second place over most important strategic technology tools (Columbus, 2014). In 2015 Gartner predicts, that IoT will have great impact on the evolution of digital business, since it has introduced new concepts of identity management and users, and devices can have complex, yet defined, relationships, as every device interacting with users has an identity (La Marca, 2015).

The IoT concept is at it highest now, with researchers and practitioners studying the technological and business aspects surrounding the phenomenon. All this information can however become overwhelming for traditional<sup>1</sup> companies seeking to survive the disruptive wave IoT brings. It can be difficult for non-technical businesses to see the benefits and value that follow IoT, or even the business opportunities. From my position within Microsoft I have daily contact to many different partners who all seek to create growth and optimization utilizing the products and services Microsoft provides. But as Microsoft’s strategy moves more and more towards Cloud and Internet of Things based services, just like many other huge IT corporations, many partner companies fall out of the horizon due to lack of experience and understanding of the concepts. Many companies, (not just traditional ones) have a hard time understanding the business opportunities within these areas, and instead of evolving their business model, making it dynamic to support these concepts they give up, keeping their business model at a static level.

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<sup>1</sup> A traditional company in this thesis is defined as a non-technology or cloud born company. It ranges from retail, healthcare, logistics, transportation, energy sector, public sector and more.

There is a huge amount of literature surrounding the subject of IoT, however most of the literature focuses on the technology behind the IoT phenomenon. But for traditional companies seeking to become part of the IoT ecosystem the technological aspect quickly becomes overwhelming or even paralyzing. The overflow of information surrounding the subject can have a negative affect on the phenomenon, as it can be challenging to navigate around IoT and get a clear understanding of how value is created in the ecosystem for businesses.

## 1.2 Clarifying the issue – the Value of IoT from a Business Perspective

According to SAP's 2014 report on next-generation business and the Internet of Things, the concept of IoT will have a significant impact on nearly every industry. This will open up for new business models as well as new sources of operational efficiencies. IoT is shifting from a hypothetical possibility to a new way of doing business, as the cost of technologies continue to fall and the ecosystem matures. There are greater demands for these "next-generation" business applications, as they must be able to capture, collect, interpret and act on vast amounts of data. Traditional IT landscapes are quickly becoming overwhelmed by the new flows of information once physical objects and places are added, where before IT systems were accustomed to information traveling along familiar and established routes (SAP, 2014).

IoT represents the future of computing and communication, and the further development of the phenomenon depends on technology innovation in RFID, sensor technologies, smart things/objects, nanotechnology, and miniaturization (Westerlund et al., 2014:5, 6). IoT is expected to change business, information, and social processes, and provide many unforeseen possibilities according to the Cluster of European Projects on the Internet of Things (CERP-IoT, 2011:10). The growth in use of connected devices and the IoT is also expected to rapidly disrupt several business sectors in the next 5-10 years (Höller et al., 2014:4). The IoT, which is often referred to as the internet's next generation, holds the potential to change our lives with a global system of interconnected computer networks, sensors, actuators and devices all using the internet protocol (Ferber, 2013). Businesses need to envision the valuable new opportunities that become possible when the physical world is merged with the virtual world, where potentially every physical object can be both intelligent and networked. When things are networked, it has an impact on how actual value is produced, and the focus has shifted from the industrially manufactured product to the web-based service that users access through those devices. Traditional manufacturing companies are seeking to remake traditional products into smart and connected ones, but embedding them into a service-based business model is much more fundamentally challenging (Ferber, 2013). An area that lacks focus from theorist and practitioners is the concept of Internet of Things based business models. The recent rapid advances of IoT have highlighted the rising importance of business model concept in the field of IoT. Despite agreement on its importance to an organization's success, the concept is still fuzzy and vague, and there is little consensus regarding its compositional facets, especially when it comes to IoT. Traditional business model theories do not capture the specifics of IoT-driven ecosystems, and extent literature have not yet provided actionable approaches for business models for IoT-driven enviroments (Turber et al., 2014).

Most literature on the subject of IoT focuses on the hyped disruptive technological side of IoT. But to get traditional businesses and industries to move towards an IoT based business model it is just as important to look beyond this disruptive technology hype and realize that sensors, telematics, machine-to-machine (M2M) and other IoT devices and technology are just the nuts-and-bolts. What really counts is the infrastructure that will hold these important technologies together - the services, apps and APIs that bring it all together - and with this business model disruption comes as well as new ways to create value (Waterhouse, 2014; Mejtoft, 2011). As former Intel CEO Andy Groves puts it: *“Disruptive technologies is a misnomer. What it is, is trivial technology that screws up your business model”* (Waterhouse, 2014). But not all companies will integrate IoT technology into their business, but rather find new ways to utilize the huge amounts of data these technologies collect and process. It is therefore highly relevant to understand the synergies and dynamics of the IoT ecosystem for these companies. According to Turber et al. (2014:17) companies are required to look at business models beyond a firm-centric lens and respond to these changed dynamics. These business models furthermore need to recognize the affordances and impacts of digitization in order to allow companies to truly tap into new business model opportunities (Turber & Smiela, 2014:1). The wealth of innovative business models forces organizations across industries to adjust their strategies in order to succeed in digital market environments. Many companies, however, have difficulties capturing the unprecedented ecosystem complexity and to develop adequate business models according to Turber and Smiela (2014:2). Turber and Smiela (2014:2) *“attempted to use existing business model approaches to identify IoT business models in workshops with companies, and found a major challenge is, that recent market dynamics in the IoT are not sufficiently explicit in the models or not addressable at an acceptable complexity”* (ibid.). These dynamics include multi-partner collaborations on digital platforms and the enhanced role of the customers as co-creator or co-producer (ibid.).

### 1.3 Research Aim and Purpose

The business model is fundamental to any organization (Magretta, 2002), due to the fact that it provides powerful ways to understand, analyze, communicate, and manage strategic-orientated choices (Pateli & Giaglis, 2004; Osterwalder et al., 2005; Shafer et al., 2005) among businesses and technology stakeholders (Mutaz & Avison, 2010). There is however very little focus on business models from an IoT perspective, and through comprehensive research in the early stage of the thesis I have only been able to identify three articles<sup>2</sup>, which seeks to provide an IoT business model framework, namely Sun, Yan, Lu, Bie and Thomas' (2012) article *“A holistic approach to visualizing business models for the internet of things”*, Turber, Brocke, Gassmann, and Fleisch's (2014) article *“Designing Business Models in the Era of Internet of Things – Towards a Reference Framework”*, and Westerlund, Leminen, and Rajahonka's (2014) article *“Designing Business Models for the Internet of Things”*. All three frameworks more or less include traditional business model theory in their research, but both Turber et al. and Westerlund et al. argue that an IoT business model

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<sup>2</sup> The method and search behind this process is explained in chapter 2.

framework must incorporate an ecosystem perspective, due to the complexity and dynamics of IoT. The three frameworks contribute to different views on the concept of IoT business models, but lack an extensive approach, which also incorporates flexibility compared to, which stage the company is in the adoption phase of the IoT concept and the different business strategies and roles that make up the ecosystem. Another important aspect when researching IoT based business models is furthermore the state of the ecosystem the business is related to, as the complexity of an ecosystem is associated with the number of participants. An early ecosystem is an unstructured, chaotic and open playground for participants according to Westerlund et al. (2014). The result is a need for IoT-specific business model frameworks that help construct and analyze the ecosystem and business model choices and articulate this integrated value for the stakeholders. Westerlund et al. highlights the need for more research surrounding business model frameworks in the emerging IoT context, which they underline as a fruitful field for developing a design tool for ecosystem business models, as IoT has the potential to not only radically change our lives, but also our ways of thinking about networked businesses.

There are therefore two main aims with the thesis; 1) I wish to clarify which aspects are most essential when researching the concept of IoT from a business and ecosystem perspective, and 2) to develop an IoT business model framework based on the extensive research done on the subject of IoT from the first aim of the thesis. The first aim is meant as an analysis of the IoT environment to further understand the dynamics and synergies in the overall IoT ecosystem. This is important to research as an IoT business model should be able to incorporate these relationships and provide an extensive method to understand these flows and activities throughout the ecosystem. A business model framework can first contribute to business value when it can be used to understand, analyze, communicate, and manage strategic-orientated choices. But an IoT business model framework must also incorporate the challenges and barriers, which goes hand in hand with IoT, as it is not all opportunities and success the concept brings with it. This is as mentioned before the different stages of innovation adoption and the state of the ecosystem the company is planning to become a part of or is already a part of. All these different and crucial aspects are essential to understand for a company wishing to become part of or play a bigger role in the IoT ecosystem today.

Furthermore, the extensive research on the IoT concept forms the basis for analyzing the three before named IoT business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014) and provides the necessary tools to review how the frameworks contribute to business value. The analysis of these frameworks are used to identify any similarities and differences, while also identifying important insights highlighted throughout the frameworks. This will furthermore contribute to the IoT business model framework developed throughout the thesis. The analysis is additionally used to support my claims that the previous mentioned IoT business model frameworks falls short in supporting and supplying the knowledge and insights needed to analyze the overall IoT ecosystem environment, which is turn can be

used to making essential business and management decisions. This in thus will provide the basis for validating my IoT business model framework.

As the picture of IoT is today, it is highly relevant to research the concept from a business and ecosystem perspective to support the foundation of an IoT business model framework. New IoT ecosystems are constantly emerging and the state and structure of these varies to the extreme. Businesses wishing to become part of an IoT ecosystem will fail if they do not comprehend the relationships in these ecosystems, and understand which role their business can play. Businesses most seek to become part of the ecosystem(s), which support their business strategy and which they share common goals with. If they fail to understand this, their presents in the wrong IoT ecosystem will create and contribute to even more disorderly synergies within the ecosystem, creating a chaotic environment with negative and even deadly consequences for the business.

The IoT business model framework developed in the thesis therefore seeks to provide a way to incorporate all the complexity in the IoT ecosystem, by providing a way to understand the dynamics and synergies between the company at the organizational, industrial and ecosystem level. The framework furthermore seeks to include a flexible approach for a business to analyze how the innovation adoption rate between the company's customers and important stakeholders affect the business position in the IoT ecosystem, as well as include the different stages there are in the ecosystem, whether the company is already a part of it, or planning on becoming a participant in an IoT ecosystem. An important aspect for companies to analyze their role in the IoT ecosystem is also understanding what role their strategy can play in the concept of IoT. The framework will therefore contribute to a holistic perspective on the whole IoT ecosystem which will have affect on ones' business, and which in turn will support the company to understand, analyze, communicate, and manage strategic-orientated choices throughout the IoT ecosystem. The research done in the thesis is therefore used to support my above claims, while diving deeper into the concept of IoT, to build an IoT business model framework.

## 1.4 Thesis Structure

In this section I will provide an overview of the thesis' structure and describe each chapter and highlight what they contribute towards. This will provide the reader with clear expectation to the thesis and its progress.

### **Chapter 1 - Introduction**

This chapter provides the reader with an introduction of the concept of Internet of Things and background information on the research of the subject so far. It highlights the issue of the lack of research of IoT from a business perspective and a failure to provide an actionable and extensive approach to an IoT business model framework. I identify three IoT business model frameworks, which are used throughout the thesis, but argue that the frameworks lack flexibility and understanding of the IoT adoption phases. In this chapter the

research aim and purpose of the thesis is proposed and I provide a summary of how I will reach the thesis' objective. Lastly a quick overview of the thesis' structure is provided.

## **Chapter 2 – Internet of Things**

In this chapter I explain the method behind the literature search of IoT, providing a summary of the steps taken to identify the literature used in the thesis surrounding IoT. This is meant to specify the boundaries and scope of the thesis, as well as clarify the research approach used. In connection to this section I also explore the implications of my research, providing an overview over the possible limitations, bias and potential problems when researching such a novel, complex and extensive subject as IoT. After this introductory part of my approach and the related issues hereof, I explore the phenomenon of IoT in-depth from a business perspective. This is done by describing the definition and vision of IoT, as well as explaining the definitions used in this thesis to describe certain concepts and aspects of the phenomenon. Next I use business ecosystem theory to help define the IoT ecosystem, which is used to illustrate the overall roles and synergies in ecosystems. To explore the IoT ecosystem more thorough I view the concept within a business and strategy concept to identify key roles and strategies in the IoT business ecosystem, namely *Enabler*, *Engager* and *Enhancer*. This section is used to understand how the different roles and strategies interact and contribute to value in the IoT ecosystem. I furthermore review the challenges and barriers related to the concept, which highlights some important elements and criteria for considerations when seeking to develop an IoT business model framework. The overall review of IoT from a business and ecosystem perspective provided me with the necessary tools and understanding to analyze and review the three IoT business model frameworks as I identified six important aspects an IoT business model framework must be able to answer, namely *Who? What? When? Where? Why? And How?* From this I developed a review tool to analyze the three frameworks, which is utilized in chapter 3.

## **Chapter 3 – Theoretical Framework**

Chapter 3 provides an extensive description, review and analysis of the three business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014). To support the review, I utilized the review tool to identify the scope and aim of the three frameworks. It likewise helped identify similarities and differences in the frameworks and provided an overview of important insights into the overall research of the IoT business model concepts so far. The findings from chapter 2 and 3 provide the foundation for the development of my proposed IoT business model framework, which I describe and review lastly in the chapter.

## **Chapter 4 – Illustration of the Framework**

To illustrate the models usability and flexibility I demonstrate the model using a case on New Orleans 911 emergency call center in this chapter. The rationale behind the case choice is further more explained in this chapter, as it is not a stereo typical business case, which usually uses a business model concept to analyze the

value creation and capture processes throughout the organization. The case contributes to a deeper understanding into the synergies and roles in the IoT ecosystem and the importance for all participants in the ecosystem to understand these synergies. The illustration of the model furthermore highlights important insight into the use of the model, and what role it can play if utilized correctly in connection with integration of IoT into ones' systems, products and services.

### **Chapter 5 – Discussion**

In this chapter I discuss the model, by reviewing the implementation of IoT, the validity of the model as well as the relevance. The discussion contributes to important insights into the legitimacy of the thesis, and the approach and findings throughout it. Discussing my model, I furthermore discuss possible future research needs and protocols.

### **Chapter 6 – Conclusion**

Next I conclude on the aim of the project, underlining the research and results. In this chapter I sum up the findings and conclude on the outcome of the IoT business model framework proposal.

### **Chapter 7 – Reflection**

Lastly I reflect on the overall process, from start to end. The thesis took numerous turns in the process to getting where it is, which I describe here. All thoughts that went into it, the past approaches and methods, as well as the failings and successes, all led to countless different insights into the phenomenon of IoT. Here I describe how the learning process and overall journey have been in retrospect.

## Chapter 2 – Internet of Things

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This chapter is dedicated to create a broad and in-depth understanding of the phenomenon of Internet of Things. However, before I explore the IoT I will first present my method and approach for selecting and structuring the literature surrounding IoT in this thesis. Next I will explore the limitations, bias and other potential issues related with such a selection and research process, as well as the different implications of researching such a novel, complex and extensive subject as IoT from such a limited perspective. These sections are included in this chapter to give a deeper understanding into what went into the evolvment of not only this chapter, but also the overall thesis.

After describing the literature selection method and potential issues involved herein, I will describe the phenomenon of IoT by defining it, and presenting different definitions used in the thesis. I will explore the vision and development behind the IoT, giving a holistic view on the IoT as a whole system made up by subsystem. The research on IoT will mostly be done from a business standpoint, but will also include different technological aspects to get a holistic understanding of the complexity surrounding this subject. It is near to impossible to purely research the business implications of IoT without including the technological aspects of IoT, as the IoT technology makes up the IoT ecosystem platforms, connectivity and networks.

This section is used to create an understanding of the IoT concept and its possibilities, challenges and barriers, for businesses seeking to become part of the IoT ecosystem. This chapter is also a necessary part of the thesis as it sets the boundary and scope of the subject and clarifies which aspects of IoT is researched in the thesis. Lastly in the chapter I will present my research findings by reviewing the literature surrounding IoT used throughout the thesis to illustrate and define gaps and shortcomings in the research today from a business perspective. In the last section I also present the most essential insights identified throughout the research of the thesis, which are important to include when researching an IoT business model solution. Here I present my IoT business model research criteria model, which incorporates the questions: *Who? What? When? Where? Why? And How?* And forms the necessary tool to analyze and review the IoT business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014), which is utilized in chapter 3.

### 2.1 Structuring the Literature Research

To conduct my research on the IoT concept and literature I followed a multi-step process. I first searched for articles published in leading academic and practitioner-oriented management journals surrounding the subject of Internet of Things using *Google Scholar*. My literature searches furthermore included reports, articles and blogs by leading organizations and individuals in the field of IoT, outside the search on Google Scholar, all focusing on the term “Internet of Things”. When searching the term “Internet of Things” on Google Scholar there are almost 2.5 million results. Further specifying the term “Internet of Things business” over 1 million results were provided, and a further specification to “Internet of Things business

model concepts” there are just over 500.000 results. However, adding the filter to include the precise phrase “Internet of Things business model” in the search there were only 13 real results<sup>3</sup>. Few of these however provided actual contribution to the concept of IoT business models, which was identified in an initial cursory analysis of these articles. The cursory analysis was conducted by reading the articles titles, journal names, abstracts, and introductions. To exclude non-relevant articles, I adopted some additional criteria for my literature review and analysis of IoT business models. For one, the literature used on analyzing the concept of IoT business models must contribute to this concept. The most literature on IoT focuses on the technology side of IoT, and though this is important to understand for businesses seeking to comprehend and develop an IoT business model, the extensive research on the technological side of IoT will only over complicate the thesis, and was therefore not included as relevant literature. The concept of innovating ones’ business model is also argued to be more sustainable than product/service innovations (Harvard Business Press, 2010). Furthermore, I wish to contribute to a sustainable and comprehensive research of IoT business models to develop an innovative and extensive IoT business model framework, where the technology side is merely just another resource or channel. Another criterion was that the literature surrounding IoT business models used in the thesis should provide a new framework or design for the IoT business model concept. I therefore did not include articles simply using traditional business model theory and frameworks to analyze an IoT business, but which also included frameworks that took a new understanding and view to IoT business models. I thereby identified the three articles by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014).

The thesis uses a qualitative method and takes a deductive approach to form the foundation for the theoretical framework for the IoT business model concept. The literature and framework is based the on three specific theoretical frameworks conducted on the subject of IoT business models mentioned earlier, by Sun et al. (2012), Turber et al. (2014) Westerlund et al. (2014). These articles will be explored in-depth, supported by theories and literature relevant to these frameworks and the overall concept of Internet of Things and business ecosystem.

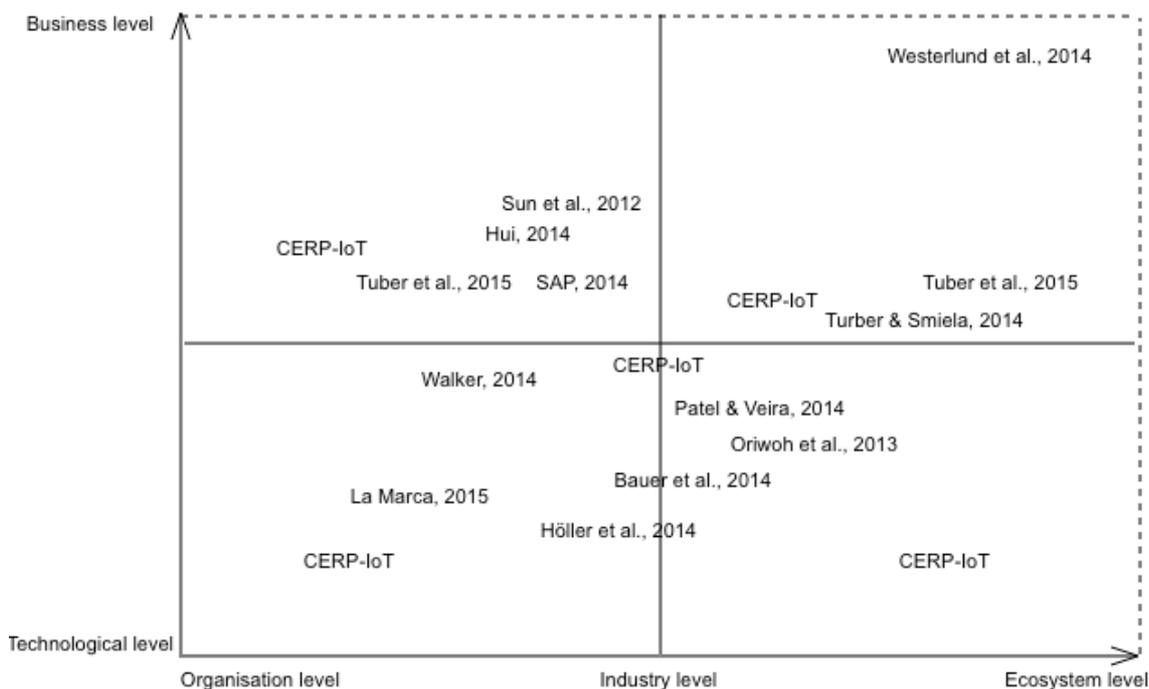
Throughout the process of the thesis, from researching the focus area to evolving the concept I have read through an extensive amount of literature, which at times was overwhelming. To limit the thesis scope I chose to discard all literature focusing purely on the technical side of IoT. The literature used in the thesis on IoT had to in some way or another incorporate business aspect in the text. For this I created three questions I used to review the texts:

1. What is the articles/research aim and focus?
2. How does it contribute to the understanding of IoT and from which standpoint?
3. How will this text be able to contribute to the research of the thesis?

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<sup>3</sup> When searching this phase the initial statement is 23 results, but only 13 are displayed.

These three questions contributed to the categorization of the literature according to where the focus area was; organization level, industry level, ecosystem level and technological and business level, which were then placed accordingly in my literature matrix as an initial stage (see figure 2.1, which is the final overview of the literature). The matrix was thus used to choose the text which were relevant to my research. The literature which fell into the extreme level of technology was discarded, as these would merely cause more complexity, and broaden the borders of the thesis scope more than it would contribute to important aspects of IoT from a business perspective. After the initial process of placing the relevant literature in the matrix I furthermore created a table as seen in Appendix A, where I dug even deeper into the texts, reviewing what type the literature was (research paper, article, industry report etc.) and what the main focus and aim of the texts was. I furthermore reviewed what the literature was based on (theories, empirical research, interviews etc.) and reviewed the important outtake of the literature, which was used in the research of the thesis (see appendix A.). From this I gained even deeper insights into the literature and again structured the text accordingly in the matrix, some of the text was categorized different than in the initial stage as I got a deeper understanding of it. The final results of the categorization of the literature can be seen in figure 2.1.



**Figure 2.1: IoT literature matrix**

Some texts are illustrated more than once, as they focus on different aspects of IoT. The literature includes various industry reports and articles by practitioners, which I deemed relevant, to incorporate empirical views on IoT businesses, opportunities and challenges. The placement of the literature in the matrix is roughly placed, as the text are more comprehensive than just focusing on one standpoint of the IoT, and mostly judged by how I utilized the texts in the thesis, and what important outtake they contributed to the

thesis as seen in Appendix A. As illustrated in figure 2.1 there is quite a gap in research surrounding IoT from a business standpoint. The review of the literature helped clarify my scope even further, as there is a lack of literature incorporating both IoT from an organizational, industrial and ecosystem viewpoint taking the business aspects into perspective. As the phenomenon of IoT is still in early stage adoption, much of the focus on IoT have been on the technological side. There is therefore very little focus and research on IoT from a business model perspective. From these articles I identified recurring elements; like the importance of defining an IoT ecosystem based on (business) ecosystem theory, the different components and relationship of these, challenges and barriers, and more.

All three IoT business model frameworks include traditional business model concept in their theoretical presentation/background (though Westerlund et al. merely touches the subject). Based on this I conducted an in-depth review of the business model and business model innovation concept (see appendix B), I decided however, not to include the review in the thesis. This was chosen as I wanted to form the IoT business model framework based on the IoT concept, rather than on a business model concept. By doing this I hoped to simplify the complexity of IoT, and thus create a comprehensive IoT business model framework, which incorporates the complexity of IoT in a simplified manner, but still providing the flexibility to view the IoT from different adoption stages, business strategies and according to the state of the ecosystem.

## 2.2 Limitations, Bias and Potential Problems

The thesis exclusively uses a qualitative research method, which is often associated with an interpretive philosophy, as researchers need to make sense of the subjective and socially constructed meanings expressed by those who take part in the research about the phenomenon being studied. Social constructionism indicates that meanings are dependent on human cognition – people's interpretations of the events that occur around them. Qualitative data are therefore likely to be more ambiguous, elastic and complex than quantitative data. It is thus important that the analysis and understanding of these data are sensitive to these characteristics to be meaningful (Saunders et al., 2012).

It is therefore imperative to keep in mind the possible limitations, bias and potential issues associated with the thesis. I have throughout the process of the thesis worked towards assimilating as much knowledge surrounding the subject throughout this period as possible. But the gaps and research needs are areas I have identified, which others might not have seen as essential as I have. I have therefore sought to incorporate sufficient literature and research to back my arguments, however without over-complicating the thesis. From the selection of my literature I have attempted to identify sufficient sources to support my argument for the issue I focus on, which I wish to clarify with the thesis, namely a comprehensive, yet simple actionable framework for IoT business model analysis. Though I have sought to be objective, a research so broad unfortunately often at times become subjective. As the solitary researcher of the thesis I can fear I have projected some interpretations to fit my conviction surrounding the importance of researching an IoT

business model framework beyond traditional business model theory, as some might view this theory sufficient to analyze IoT businesses. This is one of the greatest risk associated with a qualitative research approach, which does not include quantitative data to back the researchers' arguments up with. Another possible pitfall with my research is the lack of primary empirical data. I incorporate industry reports and articles by practitioners, but these are formed for specific uses or sectors, and therefore may result in a limited view on the concept. Another issue may be the quality of validity which lies with these texts, as some of the literature used are not all peer reviewed. All these issues have been considered through the process of developing the thesis.

To prevent these pitfalls, I have explored these issues in-depth. Close to all research surrounding IoT from a business perspective highlight the disruptive affect IoT will have on business models, due to the complexity of this phenomenon, which backs my claim that IoT must be viewed beyond a traditional business model concept. This will be discussed further in this chapter in the coming sections. Additionally, I explored the possibilities of incorporating primary empirical data, in the initial stages of the thesis. The initial method I wished to use to analyze the IoT business model concept was based on a system dynamics method, as seen in Appendix C. However, this method failed, due to the complexity of the IoT concept, and the lack of theories and data to support such an approach, which went against the initial aim of simplifying the complexity of the IoT concept, as it over-complicated the process, this is further discussed in chapter 7. Another possibility I considered was incorporating expert interviews, however due to the immature state of IoT, especially in the Danish community, this was deemed irrelevant, as it would not contribute to deeper insights into the concept, than those found in the literature. The concept of IoT is far from subjective, especially when viewing it from a business model perspective, so all relevant insights into this concept could be found through the extensive literature research on the subject. A further insurance of the quality of my research is presented in my discussion chapter, where I discuss the validity and relevance of my framework in relation to the maturing state of IoT. As the IoT is a fast evolving and dynamic environment is it also important to take actuality into consideration. What may seem like an essential issue for the concept today may be solved by tomorrow. This thesis may therefore be obsolete before 2016, this is however an extreme example of the fast moving environment, as there is likely to go some years before the IoT concept is no longer a complex issue for businesses and industries.

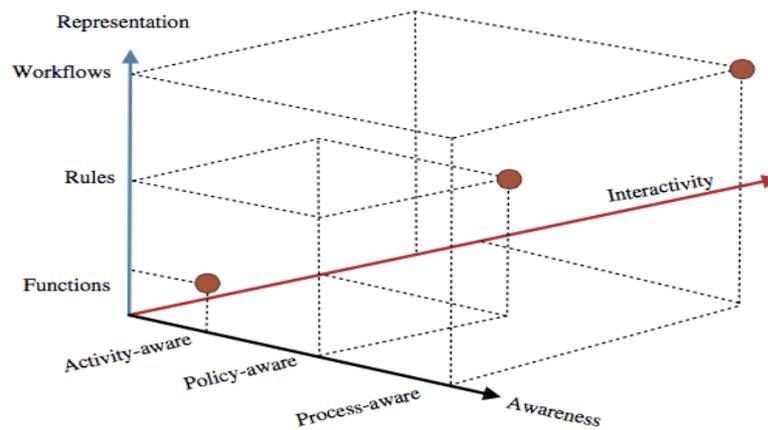
## 2.3 The Definition and Vision of IoT

The emergence of IoT was still considered with a certain degree of skepticism just three years ago – these days are long gone for some industries. IoT have become a tangible business opportunity after a series of announcements, from the acquisition of Nest Labs by Google, to Samsung Gear and health-related wearables to the development of Smart Homes and much more (CERP-IoT, 2014:1). IERC define IoT as *“a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes and virtual*

*personalities, use intelligent interfaces and are seamlessly integrated into the information network*” (CERP-IoT, 2014:3). From earlier being perceived as a futuristic vision IoT have moved to an increasing market reality. Major ICT players like Google, Apple, Microsoft and Cisco have taken significant business decisions to position themselves in the IoT landscape. Machine-to-Machine (M2M) and IoT are becoming a core business focus, as telecom operators are reporting significant growth in the number of connected objects in their networks (ibid.).

The concept and paradigm of IoT considers pervasive presence in the environment of a variety of things/objects, which are able to interact and cooperate with each other and other things/objects, through wireless and wired connections to create new applications/services and reach common goals. According to the CERP-IoT 2014 report the goal of IoT *“is to enable things to be connected anytime, anyplace, with anything and anyone ideally using any path/network and any service”* (CERP-IoT, 2014:8). Due to the fact that objects can communicate information about themselves and access information that have been aggregated by other things or be components of complex services, the IoT objects are recognizable and obtain intelligence. The IoT have finally become mainstream as start-ups and established corporations have started developing the necessary management and application software needed for the IoT’s network of physical objects, which contains embedded technology to communicate and sense or interact with their internal states or the external environment and the confluence of the efficient wireless protocols, improved sensors and cheaper processors (ibid.). The research and development challenges are however enormous in the context of creating a smart world, where the real, digital and virtual world is converging to create smart environments, which make energy, transport, cities and other areas more intelligent (CERP-IoT, 2015:15).

According to the CERP-IoT 2011 report issues related to system architecture, design and development, integrated management, business models and human involvement need to be addressed when moving towards an IoT vision built from smart things/objects. Important elements in IoT are topics like the right balance for the distribution of functionality between smart things and the supporting infrastructure, modeling and representation of the intelligence of smart objects, and programming models, which can be addressed by classifying smart objects/things as: *Activity-aware objects*, *policy-aware objects*, and *process-aware objects* as seen in figure 2.2 (CERP-IoT, 2011:13). The figure below shows a vision where an IoT environment built by smart objects is able to sense, interpret and react to external event proposed. By capturing and interpreting user actions, smart objects will be able to perceive and instruct their environment, to analyze their observations and to communicate with other objects on the Internet (ibid.).



**Figure 2.2: Smart object dimensions: activity, policy and process aware (CERP-IoT, 2011:13)**

The utilization of real world knowledge on the networking levels, as well as on the service level will enable optimizing systems towards higher performance, better user experience, while becoming more energy efficient (ibid.). The IoT uses synergies, which are created by the convergence of Consumer, Business and Industrial Internet Consumer and Industrial Internet. This convergence creates the open, global network connecting people, data and things, it furthermore leverages the cloud to connect intelligent things, which sense and transmit a broad array of data; this helps create the services that would not be obvious without this level of connectivity and analytical intelligence, these convergences therefore help push the innovation level in the IoT ecosystem. Transformative technologies such as cloud, things/objects and mobile drive the use of this platform (CERP-IoT, 2014:9).

Literature surrounding IoT businesses often incorporates different levels of activities, interactions and flows throughout the business and at different dimensions and levels. Examining IoT businesses it is therefore highly relevant to not only research opportunities and challenges from a firm-centric view, but also incorporating the industry and overall ecosystem. This therefore points to the fact that an IoT business model also must include these levels in the IoT business design. The three levels, organization, industry and ecosystem, will be defined in the thesis as the IoT value chain; normally a value chain is a set of activities performed by an organization within a specific industry in order to deliver a valuable product or service for the market (Porter, 1985). However, I argue that as the concept of IoT is usually connected to ecosystem theory, it can therefore be seen as a system made up by subsystems, each with inputs, transformation processes and outputs (CERP-IoT). The IoT value chain is therefore defined as: *Activities carried out by interacting organizations, communities, individuals and things, exchanging inputs and outputs via a platform and network to enhance the IoT ecosystem* (Porter, 1985; Moore, 1996; Muegga, 2013; Mazhelis et al., 2012) in the thesis. This is a definition put together by combining Porter's (1985) concept of the value chain as being based on the process view of organizations, the idea of seeing a manufacturing (or service) organization as a system, which is made up by subsystems each with inputs, transformation processes and outputs. Moore's (1996:26) definition of a business ecosystem as *"an economic community supported by a*

*foundation of interacting organizations and individuals*". Muegge's (2013) system of systems view, where he presents a *platform* as an organization of things (e.g. technologies and complementary assets), a *community* as an organization of people, and a *business ecosystem* as an organization of economic actors. The definition lastly incorporates Mazhelis et al.'s (2012) definition of an IoT ecosystem as the interconnectedness of the physical world of things with the virtual world of Internet, the software and hardware platforms, including the standards commonly used for enabling such interconnection. The definition therefore incorporates definitions of value creation within an organization, industry and ecosystem. To explore this further in depth the next section will focus on defining the IoT ecosystem using business ecosystem theory, which in turn will contribute to a deeper understanding of the IoT value chain.

## 2.4 Defining an IoT Ecosystem using Business Ecosystem Theory

In this section I consider the business ecosystem concept as a metaphor adopted from the biological studies to help understand and define the IoT ecosystem. I will therefore first review the concept of business ecosystem, before exploring the concept of IoT ecosystem. There is no single definition for ecosystems, however it is important to note that they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies (CERP-IoT, 2015:10). Ecosystems emerges around the core leader(s), which represents some assets commonly used by the ecosystem members (Mazhelis et al., 2012). Even though leadership roles change over time, the community values the function of the ecosystem leader, as it enables members to move towards a shared vision to align their investments, finding mutually supportive roles. Therefore, companies need to become proactive in developing mutually beneficial ("symbiotic") relationships with customers, suppliers, and even competitors (CERP-IoT, 2015:10). To help define the IoT ecosystem I will first explore the concept of business ecosystem in-depth.

The notion of ecosystem is a central concept in biology and earth science. An ecosystem is "*the complex of living organisms, their physical environment, and all their interrelationships in a particular unit of space.*" (Encyclopædia Britannica, 2010). The analogy has since spread from science to different fields and was first applied to interpret the reality of businesses by Moore in 1996. Moore (1996) declared that the term '*industry*' should be replaced with the term '*business ecosystem*', in his 1996 book "*The Death of Competition*". The term business ecosystem refers to an economic community supported by a foundation of interacting organizations and individuals. As in natural ecosystems Moore (1996) states that firms cannot thrive alone; they need to develop in clusters. He puts forward a different understanding of competition and cooperation as suggested by the title of Moore's book.

In this highly networked and dynamic environment IoT forces forward companies to increasingly adopt and design new business models to retain a competitive advantage in an environment driven by rapid developments and ever-increasing pervasiveness of digital technologies, where more and more technologies are weaved in previously non-digital products, such as bikes, watches and everyday household appliances.

This creates a major impact on the business model concept (Turber & Smiela, 2014:2). The business model definitions today are not suited for companies looking to become part of the IoT ecosystem, as they mostly do not focus outside the boundaries of a company or the company's industry. Organizations across industries are forced to adjust their strategies in order to succeed in digital market environments as IoT inspires a wealth of innovative business models (ibid.). Companies need to take an ecosystem perspective on the outcome they wish to create for users, and the structure of the value network they visualize (Weiller & Neely, 2013:1, 2). Many companies, however, have a hard time capturing the unprecedented ecosystem complexity and have difficulty developing adequate business models. This can be due to the absence of formalized means of representations, which allow a structured visualization of business models (Turber & Smiela, 2014:2). It is therefore important to understand the implications, opportunities and challenges in a business ecosystem.

A business ecosystem refers to the network, which encircles a focal firm, customers, competitors, market intermediaries, companies selling complementary products and suppliers (Weiller & Neely, 2013:2; Pilinkiene & Mačiulis, 2014:367). The ecosystem view contrast to the value chains conventional view, as business ecosystem offers a dynamic, system view, which goes beyond the value chain of a business, and also include those with rather indirect roles, such as companies from other industries that produce complementary products or equipment, outsourcing companies, regulatory agencies, financial institutes, research institutes, media, universities and even competitors (Baghbadorani & Harandi, 2012:82). Moore (1993:76) specifies, *“that a company can be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries”*. Iansiti & Levian (2004b:69) argues that the ecosystem *“also comprises entities like regulatory agencies and media outlets that can have less immediate, but just as powerful, effect on your business”*. Actors work cooperatively and competitively, in a business ecosystem, to create new products, satisfy customer needs, and coevolve capabilities around innovation (Pilinkiene & Mačiulis, 2014:367). Moore (1996:26) defines the business ecosystem as: *“An economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments, and to find mutually supportive roles.”* Moore (1996:26).

Key features of business ecosystems are interconnectedness of companies' fates, the processes of competition, and the processes of cooperation (Weiller & Neely, 2013), which together make up the concept of cooptation in relation to business ecosystem in this thesis. It is however not just between businesses

cooperation occurs, but also between business ecosystems (Baghbadorani & Harandi, 2012:82). It can be unclear as to where the borders of an ecosystem are defined due to the low level of exclusivity of businesses active in each ecosystem, as rival ecosystems within a market often share a considerable number of common ecosystem members (ibid.). The view on business ecosystem as an economic community, which gradually moves from a random collection of actors to a more structured community through a formation phase, is supported by a foundation of interacting organizations and individuals (Moore, 1993). In the formation phase innovation, technologies or concepts are identified, which will create better products and services than those already available. An initial offer targets first-user customers, who try to define the value structure, and new actors may come on board (ibid.). According to Moore (1993:76) *“Every business ecosystem develops in four distinct stages: birth, expansion, leadership, and self-renewal – or, if not self-renewal, death”*. The ecosystem stages have different competitive and at the same time collaborative challenges (ibid.). Iansiti & Levien (2002:56) argue that *“a healthy ecosystem should form a market for innovative technology components, and each firm will need to learn how to play this market and leverage components in its internal offering”*. The interactions in a healthy ecosystem between actors can contribute to business development. There are three criteria’s for assessing the health of a business ecosystem according to Iansiti and Levien (2004a), namely *robustness, productivity and innovation*. It is important that ecosystem members constantly monitor the health of their business ecosystem, and ecosystem leader(s) play a particularly critical role in regulating ecosystem health (ibid.). Being part of a healthy business ecosystem brings many advantages. Considering the fact that many businesses are operating in survival mode and many markets are seeing supply overtake the demand due to the fierce competition today. Business ecosystem opens the door to new opportunities for creating value and ultimately, gaining the competitive advantage (Baghbadorani & Harandi, 2012:82, 83). Regardless of their position in a business ecosystem, members usually invest on platforms created by ecosystem leader(s), leading to evolution and expansion of the ecosystem as a whole and improvement of the ecosystem members’ performance (Baghbadorani & Harandi, 2012:83).

In the IoT ecosystem the environment spans to the digital world as well, expanding business ecosystem theory to research the concept from a digital business ecosystem. The term digital business ecosystem was constructed by connecting digital in front of James Moore “business ecosystem” (Pilinkiene & Mačiulis, 2014). The digital business ecosystem is made up by the convergence of information and communication technology networks, social networks, and knowledge networks. The definition and goal of the digital business ecosystem is *“as a decentralized environment where enterprises interact and establish collaborations with each other. The main goal of this ecosystem is to support its actors to co-evolve in collaborative and competitive environment.”* (Pilinkiene & Mačiulis, 2014:367). Nachira, Dini and Nicolai (2007:7) argue that ecosystems *“initiative aims at helping local economic actors become active players in globalization, ‘valorizing’ their local culture and vocations and enabling them to interact and create value networks at the global level.”*

Table 2.1 shows characteristic features in the (digital) business ecosystem, such as environment, actors, key determinants affecting system performance and impact to micro and macro levels (Pilinkiene & Mačiulis, 2014:368).

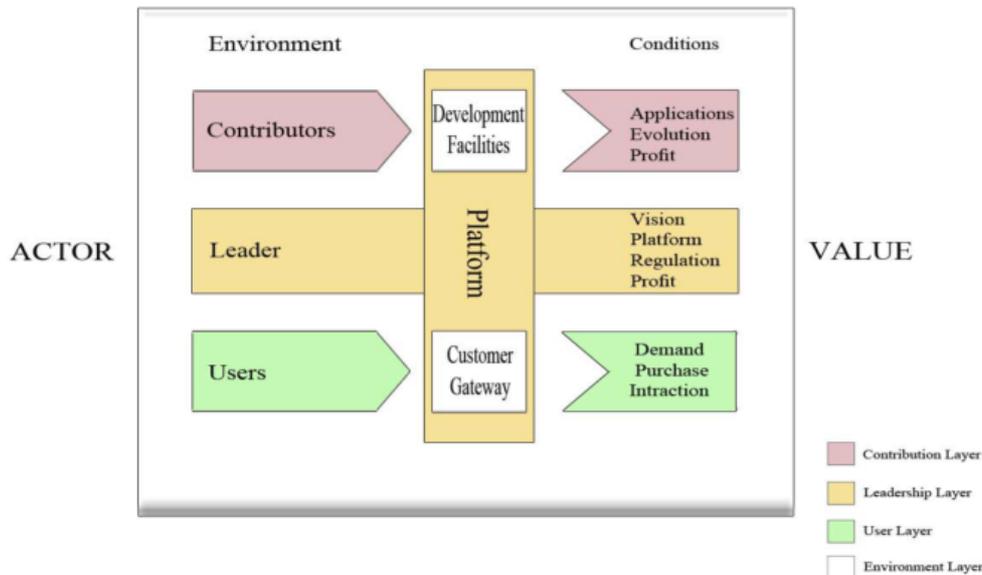
*Table 2.1: Business ecosystem vs. digital business ecosystem (inspired from Pilinkiene & Mačiulis' (2014:368) table 1).*

<b>Ecosystem types</b>	<b>Business ecosystem</b>	<b>Digital business ecosystem</b>
<b>Authors</b>	Iansiti & Levien, 2004; Moore, 1993	Nachira, 2002
<b>Environment</b>	From local to global; Interconnected business environment	From local to global; Digital environment
<b>Actors</b>	Large and small enterprises; Suppliers; Customers; Competitors; Owners; Investors; Government institutions; Other organizations	Research and education organizations; Innovation centers; Small and large enterprises with their associations; Local government and public administration
<b>Micro level impact</b>	Effect on business processes; Create cooperative networks	Provides the digital support for the economic development of enterprises; Effect on business processes
<b>Macro level impact</b>	The level of productivity; Enhance competitiveness; Enhance cooperation	Enhance competitiveness; Enhance cooperation
<b>Key determinants affecting ecosystem performance</b>	Robustness, productivity and niche creation; Interaction between ecosystem actors; Interconnectedness of companies fate	Services and technological solutions, business and knowledge; Interaction between ecosystem actors; Interconnectedness of companies fate

The level of ecosystem analogies varies, so it is difficult to list all results of business ecosystem research in one table, as there is no general unit of measurement to assess the ecosystem effects of internal actors, environmental impact and efficiency of the system (Pilinkiene & Mačiulis, 2014:369). Every ecosystem has different scopes and objectives, where the digital business ecosystem for example provides the digital support for the economic development of enterprises (ibid). When researching IoT's business model concept it is therefore important to look at it, not only from a business ecosystem, but also as a digital business ecosystem, as IoT merges these two worlds.

Baghbadorani and Harandi (2012) propose a business ecosystem conceptual model, consisting of: *Leaders, Contributors, Users, and Environment*. Leaders are at the center of the conceptual model for the business ecosystem. The leader is also referred to as 'central contributor' (Moore, 1993), and act as a hub, a chokehold without which other ecosystem members cannot continue their business life (Moore, 1993; Baghbadorani & Harandi, 2012). Leaders are able to collect a higher share of the value that the ecosystem creates, due to the decisive position they hold. The vision that the other members in the ecosystem follow is set by the leader(s), while taking a regulatory position, encouraging other members to follow its philosophy

and standards (Baghbadorani & Harandi, 2012:84). The leaders most critical role is to provide the ecosystem platform as a crucial building block of a business ecosystem. The main value of the ecosystem leader is therefore to bring a platform upon which the ecosystem is based, as it provides different parties involves, with tools and frameworks that assist them in driving innovation and improvement of their performance. A platform is defined as “*a set of tools or components that provide building blocks for application providers*” (Baghbadorani & Harandi, 2012:84) in the context of a IT ecosystem, where an application is a product that offers a solution to an end user (ibid.). Contributors exist outside the core the the business ecosystem. These are numerous interdependent organizations and individuals who contribute to the evolution of a business ecosystem, where each carry out tasks related to various areas from design, to production, operations, distribution and delivery of products, solutions and services, while all depending on each other to survive and improve their performance (Baghbadorani & Harandi, 2012:84) Contributors actively work on platforms, which the ecosystem leaders provide to improve their performance, while extending the capabilities of the platform itself at the same time. The ecosystems members’ activity and level of diversity at this layer of the model is usually high (ibid). A vital component of business ecosystems are users, they, either individuals or businesses, are the ones who purchase the products and services that business ecosystems are formed to produce. The formation of an ecosystem could therefore be meaningless without users (Baghbadorani & Harandi, 2012:84). As ecosystems are often formed around platforms, which can be viewed as a two sided business, both contributors (developers) and users are needed in order to survive and succeed. Users therefore have great importance to the success of the ecosystem, as more users result in more applications for the respective platform due to higher demand. Users are also an important factor for the health and success of platforms, as users often make assumptions about popularity of platforms and tend to choose the one with the highest number of customers, which is consequently perceived to give them access to more applications (Baghbadorani & Harandi, 2012:85). The environment, which surrounds leaders, contributors and users form the conditions in which the business ecosystem evolves. There is a strong link between organizations, strategies they adopt and the environment outside. Lawrence and Lorsch (1986) found that an uncertain environment calls for greater differentiation and consequently, more complex business processes. Environment scanning therefore becomes of utmost importance (Baghbadorani & Harandi, 2012:85). Yu et al. (2011) identified at least 6 groups forming the environment around a business ecosystem, namely, *Economic Environment, Technique Environment, Natural Environment, Social & Cultural Environment, Law & Policy Environment* and *Credit Environment*. Baghbadorani and Harandi (2012) propose a conceptual model for a business ecosystem as seen in figure 2.3 below.



**Figure 2.3: The business ecosystem conceptual model (Baghdadorani & Harandi, 2012:83)**

As described the model clearly positions organizations into 4 layers, namely leadership, contribution, users and environment. Each layer in turn have two different sides; on the left *Actor* and the right *Value*. The value side shows the value that each actor offers within the business ecosystem.

Since the essence of the IoT is the interconnection and merging of the physical world of things with the virtual world of Internet, the software and hardware platforms, as well as other standards commonly used for enabling such interconnection, this may become a core of an IoT ecosystem seen from a technology point of view (Mazhelis et al., 2012). Mazhelis et al. (2012:5) defines an IoT business ecosystem as “*a special type of business ecosystem which is comprised of the community of interacting companies and individuals along with their socio-economic environment, where the companies are competing and cooperating by utilizing a common set of core assets related to the interconnection of the physical world of things with the virtual world of the Internet*”. These assets can be in form of hardware and software product, platforms or standards, which focus on connected devices, the very connectivity, or on the application services built on top of this connectivity, or on the supporting services needed for the provisioning, assurance, and billing of the application services (ibid.).

An IoT ecosystem is constantly evolving and is heavily dynamic, and IoT innovation ecosystems could be created around specific solutions like cars, homes, hospitals and devices, and based on open platforms to deliver e.g. applications and services dedicated to connected device families (CERP-IoT, 2015:10). However, the creation of a vibrant ecosystem is limited, as IoT is still characterized by vertical silos; in that context a series of obstacles have been identified such as market fragmentation, lack of unified standards and coexistence of open and proprietary solutions, vertical focus. The lack of an established horizontal platform that is pervasive enough to structure and nurture the IoT ecosystem is a major challenge (CERP-IoT, 2015:3). The highest degree of innovation is expected to be across areas, for example cars, homes and cities,

whilst some IoT solutions will certainly remain vertically oriented to for examples address mobility or healthcare needs. However, it is unlikely IoT solutions can be economically developed across different areas with horizontal platforms enabling core service elements to be managed across verticals and companies (ibid.:3, 4). The debate surrounding the philosophical and ethical conjectures surrounding the development of IoT reached a point where it could jeopardize the business appetite for engaging in IoT. Fortunately, a new appetite for growing the IoT market and ecosystem has superseded this exploratory stage (ibid.:4).

The IoT deployment concerns complex systems and potentially addressing a large population of actors with different cultures and interest. It can however be risky putting them together to realize a system, which can operate at large scale under multiple operational constraints, as business models across complex value chains are not well understood (ibid.:11). To push the IoT ecosystem in the right direction it is important end-users and citizens drive the IoT activities and to involve existing as well as new communities in an early stage (ibid.:13). The IoT ecosystem however, also bears issues with the immaturity of innovation, as much of the IoT innovations have yet to mature into products and services. They have not yet been standardized or modularized for wider usage and often require work to couple them together in other application areas. Prerequisites for emerging markets and ecosystems within IoT are modularized objects, including “plug and play” character of components. This coupling of components can enable developers to experiment and create products and services for an IoT ecosystem, as well as learn from market experience when designing business models (Westerlund et al., 2014). To get a deeper understanding of the relationship business strategies contribute with in an IoT ecosystem, and how these different strategies interact with each other and create and capture value, I will explore IoT from a business and strategy concept in-depth in the next section.

## 2.5 IoT within a Business and Strategy Concept

Looking at the IoT from a business perspective the components can be easily sorted as so:

*“The Internet of Things and services makes it possible to create networks incorporating the entire manufacturing process that convert factories into a smart environment. The cloud enables a global infrastructure to generate new services, allowing anyone to create content and applications for global users. Network of things connects things globally to maintain their identity online. Mobile allows connection to this global infrastructure anytime, anywhere. The result is a globally accessible network of things, users, and consumers, who are available to create businesses, contribute content, generate and purchase new services”* (CERP-IoT, 2014:9). The IoT value chain’s various layers cover several distinct product or service categories like shown in figure 2.4 below.

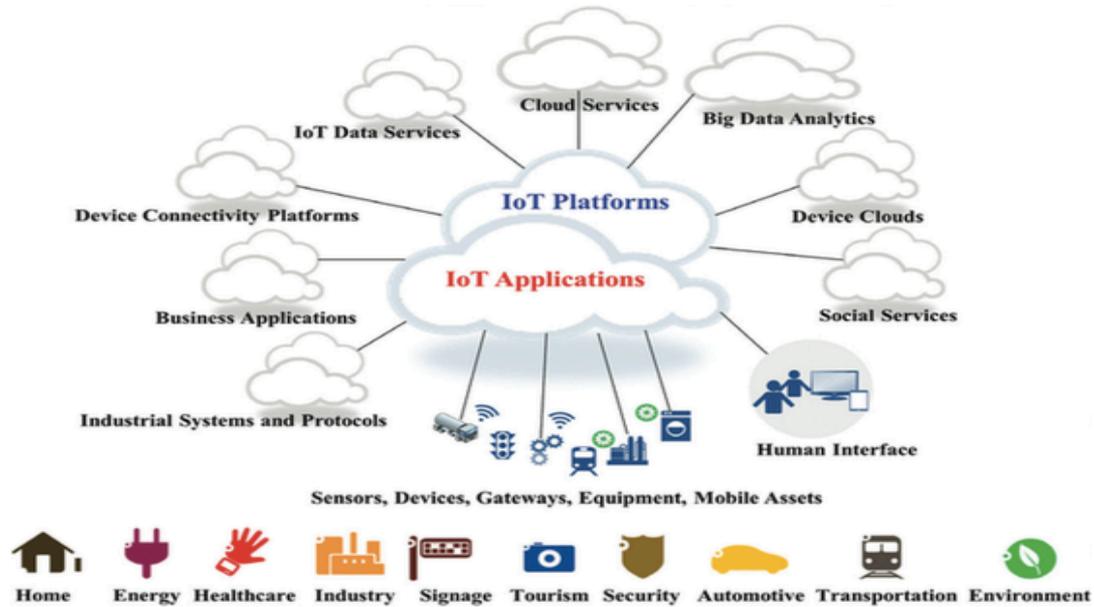


Figure 2.4: Internet of Things value chain integration (CERP-IoT, 2015:16)

Companies will compete at one layer of the IoT value chain, while many creates solutions from multiple layers, operationally competing in a more vertically integrated fashion (ibid.). When moving towards an IoT based business it is essential for the organization not only to understand the opportunities and challenges from an organizational view, but also from an industrial and ecosystem standpoint as mentioned earlier. Figure 2.4 illustrates what can be included in an overall IoT ecosystem and value chain. Other than the technology and services within IoT an organization can focus on, it illustrates the different industrial areas already being disrupted by IoT today, and together these make up an IoT ecosystem. What decides which ecosystem an organization is part of is the organizations choice of technology and service provider, however many organizations make use of multiple technology and service providers, thereby also becoming part of multiple, and even competing ecosystems. The thesis will not focus on the individual industries, but instead on the individual strategies within the overall IoT ecosystem, as strategies are easier to generalize. Throughout my research I identified three overall business strategies within IoT, namely, *Enabler*, *Engager* and *Enhancer*, which will be discussed in this chapter. These three strategies all contribute to the understanding of business opportunities and challenges on the three levels of the IoT value chain; the organization, industry and ecosystem.

### 2.5.1 Designing the Right Strategy

With a wealth of opportunities existing for companies wanting to take part of IoT it is vital for companies to understand the meaning of this new technology if it is to build value in a potential ecosystem. Early work has been on boosting efficiency and cutting cost, but to create long-term business value of IoT involves getting to know customers (both consumers and businesses) more intimately, and providing new digital services and experiences to delight them (Burkitt, 2014). The range of interconnected systems, products, and services IoT

will enable, from simple monitoring of home temperature and security to the “quantified self”, to fully networked factories and hospitals, to automated cities that respond to the movement and interest of thousands of people at once. Never have a single technological platform combined this much complexity, speed of development, global reach, and novelty among customers (ibid.).

According to Joep Van Beurden, chief executive at CSR, *“about 10 percent of this value is created by the “things,” while 90 percent comes from connecting these things to the Internet. The Internet of Things is not just about storing information in the cloud; the data only become interesting when you combine them with sensors and analytics. But a certain degree of alignment must happen for those connections to take place and for the Internet of Things to take off. The industry must adopt common standards and business models, and it must address issues relating to privacy and security.”* (Patel & Veira, 2014). Companies focusing on the things themselves should therefore find ways to support the development of a broader ecosystem and find their niche as both enablers and creators of value for their customers and their customers’ customers. This means developing partnerships with players further downstream such as companies, which are building and providing cloud-based products and services (Bauer et al., 2014). The roles that components manufacturers can play in application development in certain industries will vary, as will the timing of growth opportunities, as different industries are at different levels of maturity and complexity when it comes to IoT. Within the market for home-automation tools and monitoring products for consumers there are already a great number of application developers, and once standardizations issues can be addressed, the market may experience significant growth rather quickly. But within the retail industry for example, beacon technologies are much more fragmented and will therefore take longer to develop. All players in the value chain of retail – the stores, the data aggregators, the Internet service providers, and other partners – must sort out their roles and standards of operations before beacon technology providers can approach them with a clear customer value proposition and business model (Bauer et al., 2014).

The main stakeholders as identified by CERP-IoT’s 2015 Report (p. 179) can be summarized as follows:

- **Vendors** supplying components to the solution providers. Included in this category is a large variety of enterprises for dimensions and specializations, ranging from large global multinationals to SMEs<sup>4</sup>.
- **Suppliers** developing IoT solutions or providing IoT related services.
- **Customers/end-users** who use IoT solutions or services.

The Internet of Things arrival represents a transformative shift for the economy, which is similar to the introduction of the PC itself. It goes beyond just incorporating major technology trends such as cloud computing, data analytics, and mobile communications (Burkitt, 2014). Whole new ranges of business opportunities are opened up with IoT for a variety of players. Burkitt, a senior executive advisor at

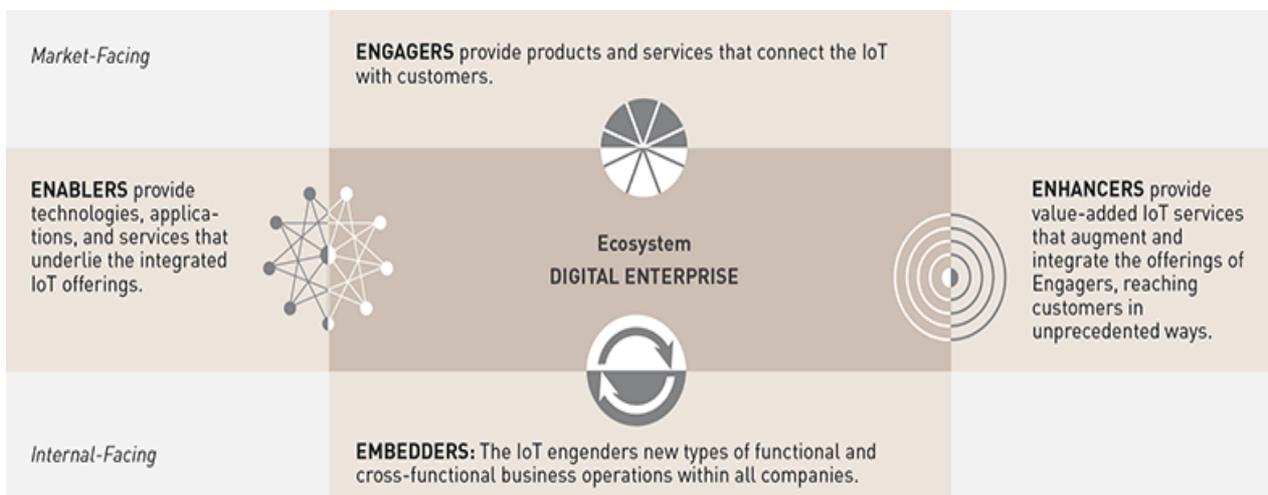
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<sup>4</sup> Small & Medium Enterprises

Strategy& places these opportunities into three broad strategic categories, each reflecting a different type of enterprise:

- **Enablers** that develop and implement the underlying technology.
- **Engagers** that design, create, integrate, and deliver IoT services to customers.
- **Enhancers** that devise their own value-added services, on top of the services provided by *Engagers*, which are unique to IoT (ibid.).

All three of these strategic categories incorporate or interact with the main stakeholders; vendors, suppliers and customers/end-users.



**Figure 2.5: The IoT Ecosystem business strategies (Burkitt, 2014)**

Figure 2.5 illustrate Enablers, Engagers, and Enhancers, which will make up the overall IoT market. The three kinds of companies will interact, and work together to provide the technology and services needed by all – both to market the IoT and to deploy it for their own operations (ibid.). Also shown in figure 2.5 are *Embedders*, these are companies who may never bring any part of IoT to market, but still have a significant role in IoT, as these companies apply sensors, monitors, and other devices to improve their own operations and optimize their own business (ibid.). Embedders will however not be further researched or described in the thesis as they are not deemed relevant for the research. Table 2.2 shows an overview of the characteristic of Enablers, Engagers and Enhancers. In the following sections a more in-depth description of the three categories is provided.

*Table 2.2: Enabler, Engagers & Enhancer characteristics*

<b>Category</b>	<b>Characteristics:</b>
<b><i>Enabler</i></b>	<ul style="list-style-type: none"> <li>• Plays well with others,</li> <li>• Friendly and flexible</li> <li>• B2B and technology orientated</li> <li>• Builds and maintains the IoT infrastructure for engagers.</li> </ul>
<b><i>Engager</i></b>	<ul style="list-style-type: none"> <li>• Creative, genius and bold</li> <li>• Use service from enablers to produce to end-users</li> <li>• Direct link between IoT and market</li> <li>• Sell disruptive products</li> <li>• Not a 'traditional' tech company</li> <li>• Understands how to gain insight</li> </ul>
<b><i>Enhancer</i></b>	<ul style="list-style-type: none"> <li>• Provides integrated services that reframe and repackage products and services from engagers,</li> <li>• Perceptive, smart and reliable</li> <li>• Finds new ways to engage with customers</li> <li>• Find new ways to create and extract value</li> <li>• Find new ways to make useful connections</li> </ul>

### **2.5.2 Enablers: Technology Builders**

Enablers are primarily technology-oriented companies, like Cisco, Google, Microsoft, IBM and Intel, building and maintaining the critical IoT infrastructure that allows Engagers to create their own connected services (Burkitt, 2014). These companies' offerings include the endpoint, hub, network and cloud service technologies, devices, connectivity hardware and infrastructure, computing and data storage systems, software platforms and much more. This market is exploding, and according to estimates the sheer growth in the number of endpoints is expected to reach 50 billion or more by 2020. Many enablers will remain content with relatively narrow businesses, as suppliers of endpoints to – or partners with – other players that have larger ambitions, while others will expand in unprecedented ways. An example of this is Intel, which traditionally is a maker of semiconductors, and is now developing soup-to-nuts IoT systems that include not just chips but development platforms that will enable others to develop their own IoT services (ibid.). The appropriate scale and scope for its business must be decided by each Enabler, based on the capabilities it can muster. Enablers can spread its efforts horizontally, becoming a broad-based supplier for IoT technology to all industries, and it can also become a primary Enabler for a specific industry, bringing together the endpoints, hubs, network and cloud services, and enhanced platforms needed in that vertical (ibid.).

The larger Enablers will fight over the enormous opportunities in integration. The system and technology they produce – intelligent endpoints, hubs, cloud services, and platforms – might go beyond just providing connections, and may also manage and bill for those connections, while allowing users to customize and develop their own services (Burkitt, 2014). The larger primary Enablers building the technology and supplying the services within IoT can be defined as Enablers of the IoT ecosystem. Their technology and services provide the platform wherein an IoT ecosystem is born. An example of an IoT ecosystem is

Microsoft's Azure platform, which provides cloud services and IoT technology and services to their partner ecosystem. This way the organization part of the ecosystem, which uses these services and technology to build more services and technologies contributes to expanding Microsoft's IoT ecosystem. An organization is however typically part of more than one IoT ecosystem, as mentioned earlier, blurring the lines of competing ecosystems. This state of the IoT ecosystem can be defined as cooptation, as organizations part of more than one ecosystem provides important insights into the competing ecosystems.

Challenges for Enabler companies are regulations, security, maturity of innovation and the technology and overall ecosystem, as well as trust and ownership, especially when it comes to data.

### **2.5.3 Engagers: Connection to Customers**

Engager companies provide a direct link between the IoT and the market. Using the endpoint, hub, platform, and service offerings created by the enablers to produce services for consumers and businesses. Many of these companies did not begin as IoT companies, and many come from non-it industries, like appliance manufacturers, automakers, insurance companies and retailers, and they expect enormous opportunities as the IoT gains traction (Burkitt, 2014). Engagers are most active in hubs and connected services. These are systems like Nest and Apple HomeKit, which provides services to customers, while collecting a rudimentary amount of data on customer usage and maintaining a high degree of customer contact. Other services provided by Engager companies, based on increasingly sophisticated IoT cloud services and platforms are more complex. For example, wearable's such as Apple Watch and Google Glasses, which can provide a wealth of location-specific data to users while collecting data about their movements (in the real world and on the Internet), their purchases, and even conversations (ibid.).

Engagers are already competing to control the nodes of human activity: the smart home, the connected car, the quantified self, the digital retailer, the intelligent factory, the next-generation hospital, and eventually the city of the future (Burkitt, 2014). It's important to have the right capabilities, and not just the most sophisticated technology or the biggest cloud to become a winner in this area. The importance will lie in knowing how to gain insights into customer needs and expectations and how to use human-centered design to develop compelling services that change how customers behave. The benefits for Engagers gaining a strong foothold in hubs and connected services include continuous and sustainable relationships with customers (ibid.).

In the past appliance makers like Whirlpool and Haier would only capture basic information about the purchaser of a washine machine; like his/her name, address, email, phone number, and perhaps some static demographic data. These companies would at most use this information to manage the warranty and send periodic notices about new products. But now, by linking the washine machine to the Internet, the appliance maker captures a wealth of data about how the device is used; these informations include when, how often, at what temperature, and with what kind of soap, as well as the kind of clothes being washed. Based on this

knowledge it can offer value-added services, including status reports on the machine's condition, suggestions for saving energy and water, and discount subscriptions for laundry detergent delivered to the home. Even traditional manufacturers can become innovators in human-centered design with that kind of information (Burkitt, 2014).

The opportunities are endless for traditional manufacturers when connecting their products to the Internet and integrating it into the IoT ecosystem. For example if the washing machine can be integrated with the house's hub, the possibilities multiply. The manufacturer could work together with the power and water utilities to establish a schedule for washing clothes at the least expensive time, using the house's HVAC system to balance the heat and humidity generated by the washine machine, and even programming the entertainment system with a playlist of laundry-day music. By providing these services the company would move beyond selling products to offering a powerful and attractive customer experience, building loyalty even as it locks customers in through the many services it can offer (ibid.).

There are however still many challenges for engager companies, which includes security and reliability, regulation, trust, integration issues, personal data, customer adoption and more.

#### **2.5.4 Enhancers: Creating New Value**

The Enhancers are just beginning to appear in the IoT ecosystem; like the enhanced services that they often deliver. Enhancers provide integrated services that reframe and repackage the products and services of the Engagers. Their success depends on finding new ways of creating and extracting value from the data, relationships, and insights generated from IoT activity (Burkitt, 2014). The insurance industry is a good example of new services created by Enhancers. Several companies are developing ways to gather data on health-related behavior to help design insurance companies rate schedules and offerings. Instead of creating their own version of quantified self, insurance companies will work with services that already exist, like the Fitbit, which measures physical activity, emerging systems that monitor heart rate, blood pressure, blood sugar, weight, and other health-related metrics; and nutrition tracking devices (which can be set up to receive automated signals from the refrigerator and restaurants). Combining this with data from additional apps and services all gathered into a hub, the insurance company can build and package value-added services personalized to each individual (ibid.). A health insurer already keeps comprehensive data on its customers' health status and past medical treatments and expenses. With customers' permission, it could augment that with individual electronic health records, combining that information with its own actuarial data, supplemented with data from drug companies, market research firms, and the government (Burkitt, 2014).

A health insurer could start building new services, by aggregating all this information. Services could include health insurance coverage tailored to individuals' needs, and premium based on their fitness habits. Customer could than receive regular health and nutrition status updates tagged to their individual medical

needs. Services could also include reminders for scheduling regular checkups and remote consultations to take advantage of their past data (Burkitt, 2014).

Emerging Enhancers today will develop new types of services, undoubtedly disrupting or surpassing today's business models. For potential Enhancers it is important to start planning for that future now; positioning themselves by focusing attention on the experience they provide their customers today. It is likewise important for them to look into technological and business issues, such as how to share data with existing hubs and services, and how to structure business partnerships. For this a strong innovating capability is needed, oriented around developing and continually updating their suite of services connected to the IoT (Burkitt, 2014).

Enhancer companies likewise share many of the same challenges as Enablers and Engagers. Many Enhancers are however at a disadvantage, as they in some cases lack knowledge about the technological opportunities and challenges within this area, as they are often come from a non-technological background. Yet, cloud born Enhancers have the opportunity to create great value and innovative services, which in turn can further promote the IoT ecosystem. The challenges and barriers, which all affect Enabler, Engagers and Enhancer strategies will be examined in the next section.

### **2.5.5 Challenges and Barriers of IoT**

Even though the opportunities are endless when moving towards an IoT business strategy and ecosystem, there are still many challenges and barriers, which need to be tackled. It should not be taken lightly when entering the fray, as the newness and heterogeneity will make it difficult to convey, even for the strongest organizations with the best capabilities and the clearest, most compelling value propositions. It is still hard to discern customer demands and expectations, and the still evolving standards for hardware and software for the IoT (Burkitt, 2014). One of the roadblocks related to building IoT ecosystems is the lack of employee skills/knowledge, which is reported to be a significant obstacle facing organizations using IoT technologies (CERP-IoT, 2015:9) There is a need to integrate billions of endpoints and intelligent devices, the data they produce must be managed and analyzed, which is a huge and complex task for organizations (Burkitt, 2014). Another issue is related to regulatory and standardization obstacles, and governments and other regulator has begun to focus on IoT. There are a number of questions surrounding regulation and control over the IoT, like who, if any one body should control the IoT? Should it be self regulated or government controlled? It may be deemed necessary, for management and marketing purposes, to introduce a system for storing records of all tagged (or IoT-enabled) objects (Oriwoh et al., 2013). The EU commission has published a report on the result of its public consultation on the IoT, where it especially focuses on loss of privacy and data protection. The regulatory and standardization issues include consent, profiling, privacy policies and enforcement and sanctions (Walker, 2014). There is a greater expectation from consumers to have more control over their personal data, as issues surrounding the privacy of tracked information and sensitive data (such as e-health records) are ongoing, and vulnerability concerns of devices and clouds that make up the IoT are growing, as

more focus is placed on hackers and malicious code issues and as new technologies are developed and unveiled it typically triggers new cypercrimes (Burkitt, 2014; Oriwoh et al., 2013). This results in companies and entire industries being reluctant to share data with other enterprises in an IoT context, given these unknowns about stability and security (Burkitt, 2014) and will be a huge barrier for entering the IoT ecosystem. IoT furthermore raises privacy concerns in relation to smart objects, as smart objects will collect more and new kinds of data, including personal data, where this data will automatically be exchanged, which may lead to a perception of loss of control by citizens/end-users. Ethical questions are additionally provoked by the IoT concept; these particularly pertain to individuals' autonomy, accountability for object behavior, or the precautionary principle (CERP-IoT, 2015:9). Examples of objects being hacked have shown that the development of IoT and its integration in systems enabling key economic and societal activities may raise security and resilience issues, which will require further organizational measures.

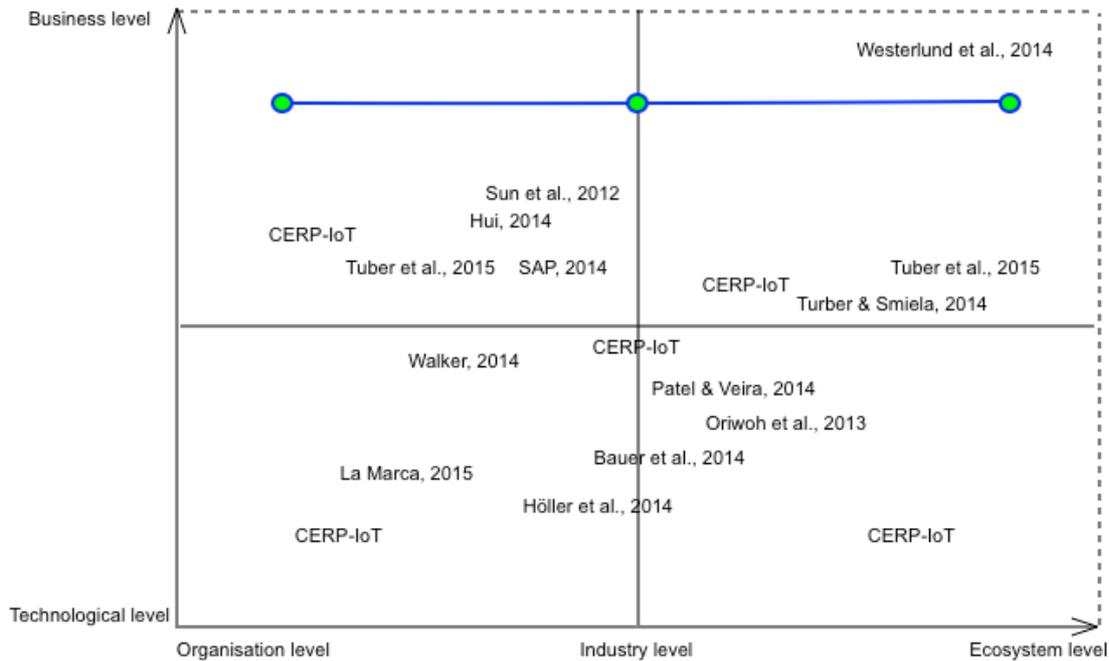
Another important issue that will need to be addressed is liability when related to situations where wrong decisions are taken by smart devices and connected systems. This will be critical for citizens' acceptability of the technology, and can result in adoption problems. When promoting proper deployment conditions education and legal guidance will play a huge factor, when making sure IoT serves genuine value and benefits for the end-users, and avoid the perception that IT could lead to a dehumanized society controlled by machines and/or a reinforcing of the digital divide and of social rejection (CERP-IoT, 2015:9). It is important that IoT includes and promotes fundamental rights, protection of integrity, inclusion, and openness, fair competition and open innovation (CERP-IoT, 2015:9). For organizations who want to stake a claim of the IoT will need to develop a distinctive "way to play" – a clear value proposition the company can offer their customers. The value proposition should be consistent with the organizations overall capabilities system; the things the organization does best when going to market, aligned with most or all of the products and services one sells (Burkitt, 2014).

An organization must include these challenges and barriers into their IoT strategy considerations and plan accordingly. With the right strategy and value proposition on place an organization can gain great traction in the IoT ecosystem. There are however many examples of companies failing to comprehend the risk associated with integrating IoT technology, without the necessary risk assurance in place to tackle possible attacks. An example of this is the case of Target in 2013 (see appendix D), where malware was installed in Target's security and payment system, and managed to steal 40 million credit card numbers, even though Target had installed extensive security systems (Riley et al., 2014). The breach was discovered early enough by the security system to stop the breach, but Targets lack of skill and understanding of the security process allowed the breach to happen seamlessly. The initial intrusion into its system was traced back to Targets HVAC's network connection, and questions have since been why Target would give an HVAC company access to the internal network without setting the necessary security precautions to cut of the connection to the payment system network (Riley et al., 2014). The intrusion resulted in damage cost running up into the

billions, as well as lost of their customers' trust. This is an example of an extremely negative affect by installing IoT technology into some part of the company's system without comprehending the risk associated, and without possessing the necessary capabilities on safeguarding against such risk. Timing and the right capabilities are therefore a huge factor when moving towards the IoT ecosystem.

## 2.6 Internet of Things Research Criteria Components

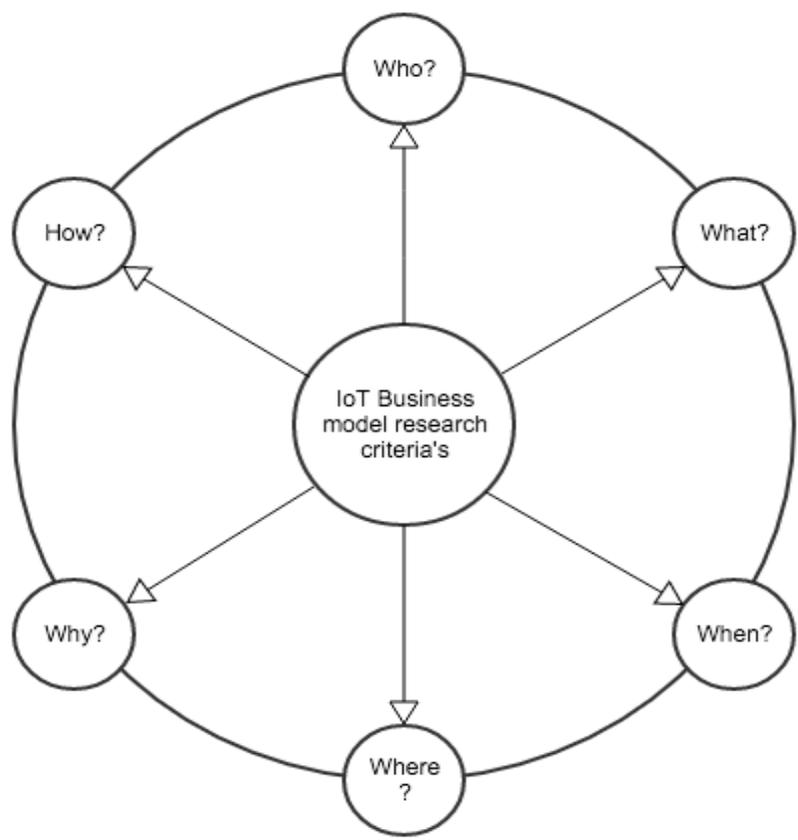
The overall research process of the IoT concept highlighted many important aspects which needs to be taken into consideration when analyzing the concept of IoT business models. Much of the literature surrounding IoT is as mentioned focused on the many aspects of interconnectivity, sensors, networks, integration and overall technology. The literature that does focus on the business aspects of IoT usually puts it in context with ecosystem theory. IoT merges the physical world with the virtual world, thereby also removing country borders and cultural borders. IoT opens the door for endless possibilities for organizations willing to take this leap, but also brings many challenges, barriers and risk associated hereof. This is not just from a business perspective, but also from a legal and public standpoint, as regulatory standards on the area are still in a working process. When we open our life up to become even more digitalized we also become more vulnerable to virtual attacks, which very few people know how to deal with, and if we are attacked whose responsibility is it cover these attacks? Is it the producer of the product or service, is it the network, or does the risk lie with the end-user? There are many areas of the IoT concept which requires extensive research, especially for a business seeking to plan ahead or move towards an IoT ecosystem. A possible business model framework for the concept of IoT must therefore include all these aspects into the analyze, so companies can make structured and informed decisions based on their possible position in the IoT ecosystem and the risk associated with this. The literature matrix used in section 2.1 identified an essential gap in the research of IoT businesses, there is very little research focusing of all levels of the IoT value chain; the organization, industry and ecosystem from a business perspective as seen in figure 2.6. Research usually only takes one or two or these levels into consideration. But this may have a negative affect if the company does not comprehend the importance of incorporating all necessary information gathered throughout the three levels of the IoT value chain.



**Figure 2.6: Thesis' blue ocean focus space**

The thesis therefore includes all these aspects when viewing the criteria needed to provide an extensive IoT business model framework. As mentioned I identified three strategic categories within the IoT ecosystem, namely Enablers, Engagers, and Enhancers. Some organizations can even take on more of these strategies, if they possess the right capabilities and can fit it into their value proposition. But a more important question many companies should ask themselves when it comes to IoT is “when?”. If a business decides to move towards an IoT strategy, they must ensure the timing is right for them. Taking the popular model of technology adoption lifecycle (Moore, 2006) into consideration, it recognizes five types of adopters of innovation, namely, innovators, early adopters, early majority, late majority, and laggards. For an IoT business there lies a challenge to advance from early adopters to early majority, as business models must allow for “scaling up” the business. Early adopters are willing to tolerate the immaturity of innovation, while early majority likes to evaluate and buy whole products, including the product, ancillary products, and related services (Westerlund et al., 2014). Some however, argue that the big-bang disruption, which is enabled by the new digital platforms, which go hand in hand with IoT, does not follow the five-step model, as new products are perfected by few trail users and are then embraced quickly by the vast majority of the market. For the concept of IoT to grow and become a relevant factor in all industries and in all companies in one way or another the innovation, which lies within this concept must be mature enough for customers to adopt it rapidly. Timing therefore plays a huge factor when moving towards an IoT business, which in turn creates more dimension and complexity for a business model design in IoT. For a business model concept to handle the complexity of IoT it needs to structure this complexity, and therefore incorporate more than the usual “Who?”, “How?” and “What?” questions traditional business models seek to answer, but also include the “Where?”, “Why?” and “When?”.

For this I have created figure 2.7, which incorporate all these criteria's, and will be used to review and analyze Sun et al. (2012), Turber et al. (2014) and Westerlund et al.'s (2014) three IoT business model frameworks. Figure 2.7 will be used to examine the IoT frameworks and view what specific business model questions the frameworks answer. Traditional business model frameworks merely seek to answer who, how and what. However, in an IoT business standpoint these will fall short of giving a full overview over the IoT ecosystems opportunities and challenges, as a business must not only view the business model from a firm-centric standpoint, but also from an industrial and ecosystem perspective. Figure 2.7 is furthermore used to better comprehend and structure the complexity in the IoT ecosystem.



*Figure 2.7: IoT business model research criteria model*

In the next sections I will outline the different criteria's the IoT business model should incorporate. All criteria's must be viewed from an organizational, industrial and ecosystem level.

### **2.6.1 Who?**

The “who” answers the equivalent as traditional business model frameworks; who are the key partners, customers/consumers, and stakeholders. But it also goes beyond these and seeks to answer who is/are the ecosystem leader(s), who are the competitors, and is or can the relationship be seen as a cooperation. Before moving towards an IoT business the organization must also ask who are their employees, and what are their capabilities and skills, does the company have the right resources, or does it need to acquire better skilled

people to help position the company in the IoT ecosystem. Overall all actors who in some way or another comes in play with the business should be reviewed, as well as possible future partners, customers and competition.

### **2.6.2 What?**

When examining the “what” an IoT business model should include the channels, customer relationships, segments, key resources, cost structure, value proposition, value drivers, needs, links, value exchanges, value extracts, flows, and core value and other relevant activities. This is done throughout the value chain, starting from the business to the industry and lastly the overall ecosystem, to get a picture of what activities create what value. It is also here the company view their motivations, and can realize innovation. These are the flows and activities which creates value and the “why” factor. But the “what” factor can furthermore be used to identify the state of the IoT ecosystem; what are the key factors that structure the ecosystem? what create unstructured environments in the ecosystem, etc.

### **2.6.3 When?**

With the instability of innovation and adoption within IoT the “when” factor plays a huge role. This can be the difference between succeeding or failing. It may not always pay off to be a first-mover in the IoT ecosystem, as the company’s industry, capabilities, resources, and even customers, play a huge factor. The organization must use the “who?” and “what?” to pinpoint what kind of adopters their customers and main stakeholders are, and which capabilities are the company’s stronghold, before committing to become a larger part of the IoT ecosystem. The “when” can also help the company renew itself, which is an important stage of the ecosystem according to Moore (1996), and even give birth to new types or parts of ecosystems.

### **2.6.4 Where?**

The “where” can be understood in different ways, all according to what the company’s needs are. The “where” might be seen in terms of the digital layers of IoT ecosystem, like layers of devices and products, connectivity, services and content layers, which may represent a distinct source of opportunities for collaborators to contribute to the value creation process (Turber et al., 2014). It can also be viewed from a market perspective, looking at the different layers of the market and IoT ecosystem, to research if the company can expand to other adjacent markets. From a value exchange view a company may research where the most profitable value exchanges lie, and where the information flows from.

### **2.6.5 Why?**

The “why” falls under the value proposition, which goes hand in hand with “what” and “how”. This part helps outline each essential actor (collaborators, customers, stakeholders, partners) “reason” to participate in the ecosystem, and is meant to depict all monetary and non-monetary benefits, which attract the different actors to participate in the ecosystem. This is also where the different value extracts are found, and helps highlight the relevant nodes and exchanges that are required for value creation and capture. The “why” can

help focus on a relevant portion of the ecosystem to e.g. pinpoint something that is beneficial from the company’s point of view. It is therefore a good tool to zoom in and out of the ecosystem to define the core value for the organization and in turn the industry and ecosystem, and its underlying aspects in the overall ecosystem (Westerlund et al., 2014).

### 2.6.6 How?

The “how” includes various activities, processes, and networks to apprehend which flows are linked to create value. These may also include autonomous actors, such as smart sensors, pre-programmed machines, and linked intelligence. The “how” also defines how value is exchanged and in which level of the IoT value chain. This criterion furthermore looks at which means, resources, knowledge and information are used to create and capture value throughout the IoT value chain. But it can also be used to identify how the ecosystem is structured or even unstructured, to identify the state of the ecosystem.

### 2.6.7 Review Tool

The outcome of the literature review and criteria model was a review tool to help review the three IoT frameworks by Sun et al. (2012), Turber et al. (2014), and Westerlund et al. (2014) as seen in table 2.3. In chapter 3 I will utilize the tool to identify where the focus area is for the different frameworks, and what the frameworks aim toward clarifying. The review tool will highlight to what extend the frameworks focus on the concept of IoT business models from an organizational, industrial or ecosystem perspective, as I earlier argued the importance of including the whole IoT value chain when researching IoT business models.

*Table 2.3: Review tool to analyze IoT business model frameworks*

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>			
<b>What?</b>			
<b>When?</b>			
<b>Where?</b>			
<b>Why?</b>			
<b>How?</b>			

The tool is furthermore included to identify the important questions the three frameworks seek to answer and clarify, as well as identify possible similarities and differences between the frameworks. The overall result from the analysis will support the development of my IoT business model proposal, as well as provide insight into the models relevance.

## Chapter 3 – Theoretical Framework

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In the following chapter I will provide an extensive description of the three IoT business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014). These descriptions will give the reader the necessary information of the theories and approaches used in each framework to provide the foundation for the IoT business model concepts. It also provides insights into how the approaches differ between the three frameworks and from the research approach used in this thesis. After each description I will provide a critical review, where I analyze and review the frameworks used theory, approach and outcome. To perform the critical review, I utilize the review tool developed in the previous chapter. The tool provides a manageable approach to identifying similarities, differences and other important insights into the frameworks. The tool furthermore provides a way to incorporate the dynamics and complexity of the IoT ecosystem in a simplified manner.

### 3.1 Analysis of the three IoT Business Model Frameworks

This research focuses on three earlier works on the concept of IoT business models. These articles were chosen as they all seek to contribute to the understanding of IoT from a business model perspective. They each focus on different elements from a business model view, and all take very different approaches to defining an IoT business model framework. Table 3.1 shows a quick overview over the three research papers' contributions to the IoT business model framework, which I will explore further.

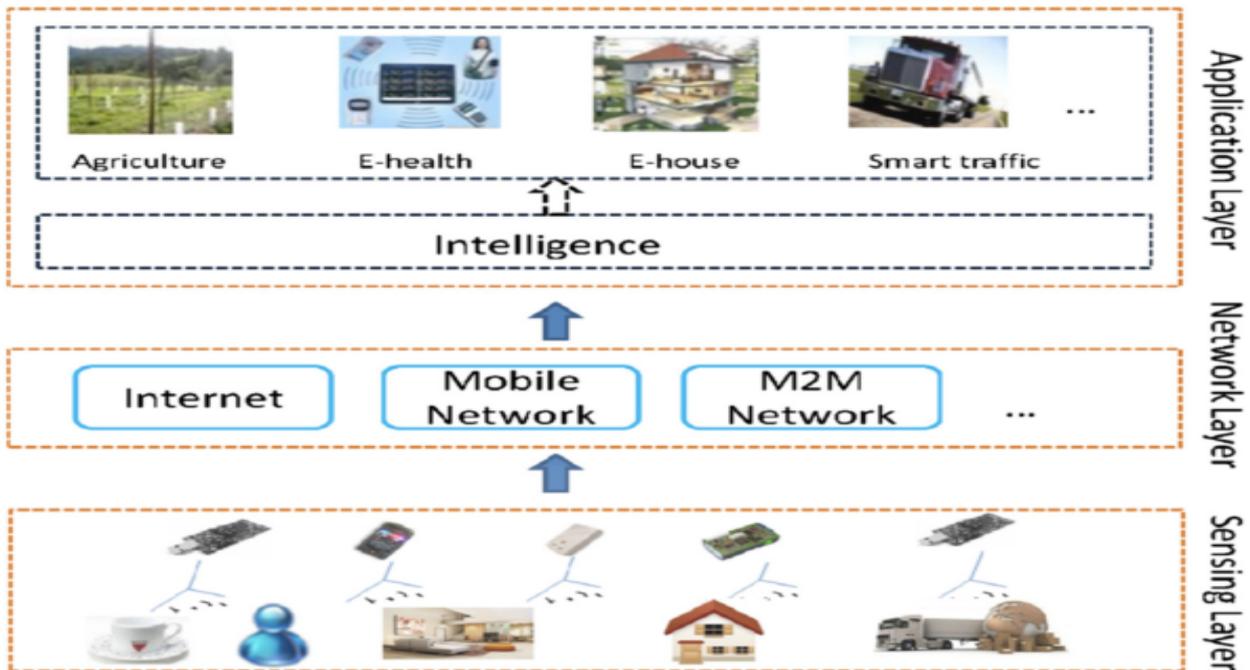
*Table 3.1: Literature overview of IoT business model frameworks*

Authors, year	Framework	Components
Sun, Yan, Lu, Bie, & Thomas, 2012	<p>IoT business model as a Business DNA Model – a representation of business model in terms of <b>Design, Needs, and Aspiration</b>.</p> <ul style="list-style-type: none"> <li>• Uses theories on business model and business model innovation.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Design (how?)</b> <ul style="list-style-type: none"> <li>▪ Key Partners (KP)</li> <li>▪ Key Resources (KR)</li> <li>▪ Key Activities (KA)</li> </ul> </li> <li>• <b>Needs (What?)</b> <ul style="list-style-type: none"> <li>▪ Channels (CH)</li> <li>▪ Customer Relationships (CR)</li> <li>▪ Customer Segments (CS)</li> </ul> </li> <li>• <b>Aspirations (Why?)</b> <ul style="list-style-type: none"> <li>▪ Value Proposition (VP)</li> <li>▪ Revenue (RS)</li> <li>▪ Cost (CS)</li> </ul> </li> </ul>
Turber, Brock, Gassmann & Fleisch, 2014	<p>A business model that captures the specifics of IoT-driven ecosystems.</p> <p>The framework presents the IoT business model as an artifact, which is a network-centric, 3-D framework consisting of 3 dimensions: <b>Who, Where, and Why</b>.</p> <ul style="list-style-type: none"> <li>• Uses theories on ecosystem, value network, information systems, and</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Who</b> <ul style="list-style-type: none"> <li>▪ Partners, customers, stakeholders</li> <li>▪ Collaborator 1, 2, 3 ...</li> </ul> </li> <li>• <b>Where</b> <ul style="list-style-type: none"> <li>▪ Device</li> <li>▪ Network</li> <li>▪ Service</li> <li>▪ Content</li> </ul> </li> <li>• <b>Why</b> <ul style="list-style-type: none"> <li>▪ Monetary benefits</li> </ul> </li> </ul>

	service-dominant logic	<ul style="list-style-type: none"> <li>▪ Non-monetary benefits</li> </ul>
Westerlund, Leminen, & Rajahonka, 2014	<p>The framework proposes a new design tool for ecosystem business models. They suggest that <b>Value Design</b> is a more appropriate term for an IoT business model.</p> <p>Key pillars in the <b>value design</b> are: <b>Value drivers, Value nodes, Value exchanges, and Value extract</b></p> <ul style="list-style-type: none"> <li>• Uses theories on ecosystem and value creation and technology adoption</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Value drivers</b> <ul style="list-style-type: none"> <li>▪ Promote the birth of the ecosystem</li> <li>▪ Fulfills a need</li> <li>▪ Value nodes motivational factor</li> </ul> </li> <li>• <b>Value nodes</b> <ul style="list-style-type: none"> <li>▪ Actors</li> <li>▪ Activities</li> <li>▪ Processes</li> <li>▪ Linked with other nodes to create value networks</li> </ul> </li> <li>• <b>Value exchanges</b> <ul style="list-style-type: none"> <li>▪ Exchange of value by different means, resources, knowledge, and information</li> <li>▪ Occurs between and within different value nodes</li> <li>▪ Flows are tangible and intangible</li> <li>▪ Shows how the engine works</li> <li>▪ How value is generated and distributed</li> </ul> </li> <li>• <b>Value extract</b> <ul style="list-style-type: none"> <li>▪ Identifies the value that can be monetized</li> <li>▪ Identifies nodes and exchanges that are required for value creation and capture</li> <li>▪ Defines the core value and underlying aspects in the ecosystem</li> </ul> </li> </ul>

### 3.2.1 IoT Business Model as a Business DNA Model (Sun et al., 2012)

Sun et al. (2012) takes a holistic approach to visualizing business models for IoT. They argue that a broader development of the IoT will have many challenges ahead, and that economic factors might be the biggest barrier. Sun et al. identify three layers of the IoT; a sensing layer, a network layer and an application layer. They argue that the deployment cost is the most important in the sensing layer, as they impact data acquisition and utilization, as reduction of sensor cost will enable massive amounts of data to be used economically. The network layer aims at disseminating large quantities of real-time and multitudinous information. Customers will be able to find the highest quality goods at the lowest cost, while businesses can acquire customer behavioral data and control inventory. These information exchanges will no longer take place among people alone, but extend to taking place between people and things, and even just among things. The most important feature in the application layer is intelligence, while the data processing center is a central feature of the intelligence in the IoT. Sun et al. illustrate the IoT structure in figure 3.1.



**Figure 3.1: The Structure of the Internet of Things (Sun et al., 2013:2)**

Sun et al. emphasize that there is a lack of business models to describe these layers and how they interact, which is evident in IoT. In an IoT business model context it is currently hard to answer simple questions like: “What is the value proposal? What is the cost and benefit? How does a company profit from the IoT technologies?” (Sun et al., 2012:2).

The aim of Sun et al.’s article is to develop an operable business model based on DNA Model, from the perspective of designing a business model in the IoT. They reveal that business model innovation holds the potential of reforming existing or creating new business models, and argue that these can furthermore bring continuous financial or nonfinancial benefits for companies to flourish (Sun et al., 2012:2). To form the Business DNA model for IoT Sun et al. utilize theories on business model and business model innovation.

Sun et al. highlight the advantages for companies developing business models for IoT early on, as this will enable companies to gain first-mover advantages during the development of IoT, as well as speed up the pace of transformation or strategic realignment to meet challenges of IoT. Companies who are already focusing on business model development of IoT will also better be able to seize the opportunities this brings (ibid:3). When innovating business models for IoT Sun et al. (2012) propose to address the following elements (ibid.:3, 4):

- Customers: Who are the core customers? Where are they? Have they changed?
- Markets: Have the company’s markets changed? Should the company change their market position?
- Channel: Which channels are used to offer product/service?
- Infrastructure: Who are the key partners? What are the key activities? Where are the available key resources?

- Value: What is the value offered to customers?
- Revenue & Cost: does the revenue exceed the cost?

Sun et al. (2012) present their business DNA model (figure 3.2) for the IoT consisting of three modules; D or Design block (the how?), N or Needs block (the what?) and A or Aspiration block (the why?).

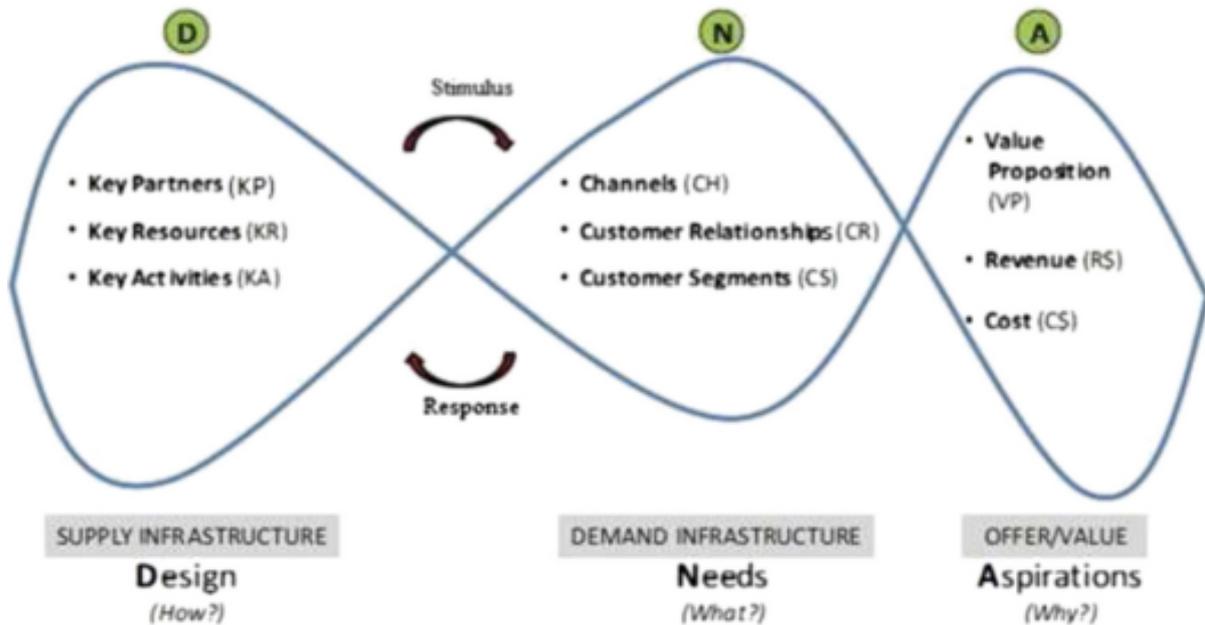


Figure 3.2: Business DNA model for the Internet of Things (Sun et al., 2012:4).

The D or Design block refers to elements of the given system, and deals with the question of “How?”. This supply infrastructure consists of three elements: key partners, key resources and key activities. The N or Need block focuses on the players in the external environment and deals with the question of “What?”. The N block consists of three categories of elements as the external or demand infrastructure of a business model: channels, customer relationships and customer segments. The last module A or Aspirations block deals with results and responds to the question of “Why?”. The A block deals with the three elements of value: value proposition, revenue and cost.

The three modules influence and complement each other. The A-block refers to the ultimate *ends* to be achieved by the organization, and the N and D-block consist of the *means* to achieved the *ends*. The N-block focuses particularly on the *external* infrastructure for satisfying needs of the customer, market, and stakeholder. The D-block covers elements of the organization’s *internal* infrastructure for supplying a product or service. Overall Sun et al.’s framework seeks to provide an easy-to-use approach for practitioners to grasp business opportunities and to present stories, models, and projects for IoT. To illustrate their model, Sun et al. uses a case study on Logistics, as this is one of the earliest application areas within IoT. Figure 3.3 illustrates Sun et al.’s DNA business model in smart logistics, where they identified the different actors, activities and components through the analysis of the logistics case.

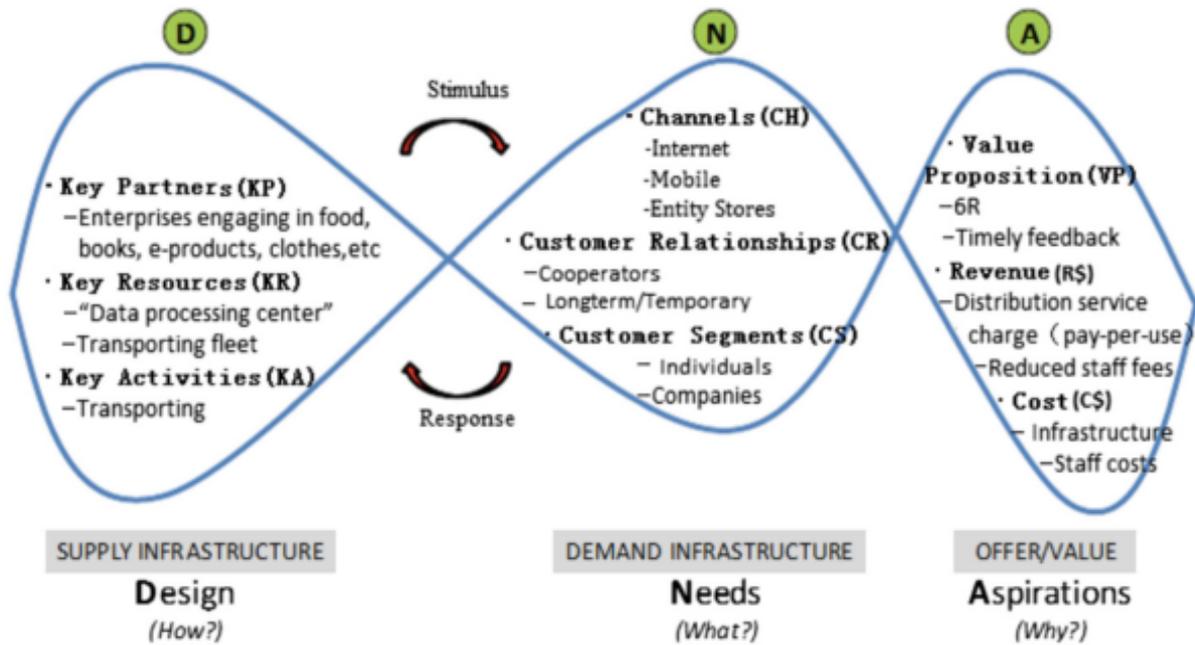


Figure 3.3: Sun et al.'s DNA business model in smart logistics

Sun et al. (2012) compares their DNA model with other business model frameworks, which represents either a business model at the enterprise level or at the industry level. The most common enterprise level frameworks include the Value Chain, Strategy Map, Four-Box Business Model, and Business Model canvas, and at an industry level they name Five Forces, Value Net, Supply Chain, and Business Model Environment. Value Chain and Business Model Canvas are the most widely used, among these models, in both academic and practical circles. As the Business Model Canvas can be printed out in a large surface for people to understand, discuss, create, and analyze, it provides a very visual approach to the business activities. It designs a business model with the four elements of value proposition, infrastructure, customers, and finances (Sun et al., 2012:6). Sun et al. (2012) however argues that the Business Model Canvas does not illustrate a clear cause and effect linkage between 'means' and 'ends' and it is complex and time-consuming to develop multi-level business model analysis, design, and management in the Business Model Canvas, as the enterprise and industry business models have different visual formats. They argue, that in contrast the DNA Model uses a consistent visual format at both levels. The underlying logic of the model is a linear cause-and-effect or input-processing-output relationship. The DNA models inherent structure is a linear fractal: the basic visual structure and relationship between the DNA blocks – design, needs, and aspirations – are the same at any level of the business model. According to Sun et al. (2012:6) the linear fractal structure of the DNA Model greatly simplifies presentation, understanding, analysis, design, and planning of business models especially within and across industries.

### 3.2.1.1 Critical review on Sun et al.'s DNA business model

Sun et al. (2012) offers a highly simplified contribution to the IoT business model concept, which is mostly based on business model and business model innovation theory and concepts, and only including very little

theory on IoT. The framework focuses on the “how”, “what” and “why” questions surrounding the organization itself and on the industry level. It can also be argued that the DNA business model can be extended to the overall ecosystem as it includes channels, which can include the network the business is a part of, but this is not included in Sun et al.’s model description. The DNA model furthermore illustrates the cause-and-affect or input-processing-output relationship and uses a consistent visual format at organizational and industry level.

There are however some gaps in their framework, as it falls short of including the overall IoT ecosystem the organization is part of as a more extensive part of the business model. They review IoT as a three layered environment, including sensing, network and application into these layers. It thus lacks the complexity of the IoT concept, such as the dynamic and innovative environment which calls for quick adoption needs, or a way to include a timeframe for future adoption. These elements can be essential for businesses seeking to move towards an IoT business model, but must first review the risk associated here. The DNA business model therefore does not provide a user-friendly overview for businesses new to the IoT ecosystem.

The questions Sun et al.’s framework seeks to answer are illustrated in table 3.2. In the introduction of the article Sun et al. argue that it is currently hard to answer questions such as “*What is the value proposal? What is the cost and benefit? How does a company profit from the IoT technologies?*” and furthermore argues that business model innovation holds the potential of reforming existing or creating new business models. These questions are to some extent answered when utilizing the DNA business model, but still have a hard time giving an extensive view into the IoT ecosystems possibilities and challenges.

**Table 3.2: Focus and aim of Sun et al.’s DNA business model**

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>	- Key partners - Customer segments	- Customer segments	
<b>What?</b>		- Channels - Customer relationships - Customer segments	
<b>When?</b>			
<b>Where?</b>	- (channels)	- (channels)	
<b>Why?</b>	- Value proposition - Revenue - Cost		
<b>How?</b>	- Key resources - Key partners - Key activities		

The DNA business model additionally only focuses on one level at the time, as D and A blocks refers to the elements of the internal infrastructure and the N block focuses on the external infrastructure. As I earlier argued, the industry and ecosystem is an extension to the organization in the IoT ecosystem, as IoT opens up for new unforeseeable partnerships and competition when a company becomes part of the ecosystem. The DNA business model is mostly suitable for engager companies who are not seeking to expend into new

markets right away, like a Smart Logistics company that Sun et al. used to illustrate their business model. The outtake of the DNA model is merely an extension to traditional business model by including business model innovation, but very little focus on the overall IoT ecosystem and literature surrounding the IoT concept. The model includes the organizational and industrial view, but lacks flexibility and usability for organizations planning on integrating some sort of IoT technology or services into their business.

### **3.2.2 IoT Business Model as a Network-Centric 3-D Framework (Turber et al., 2014)**

Turber et al. (2014) describes IoT as a driving force where digital technology gets increasingly weaved in previously non-digital products, like bikes, clothes and everyday household appliances, and is expected to have a major influence on the nature of products and services, and in consequence on overarching business models, like the overarching logic of how businesses work. The features of IoT open up numerous opportunities for novel services and business models within an emerging ecosystem of new collaborators., and in general IoT inspires a wealth of new business models, which frequently involve diverse partners of thereby arising cross-industry ecosystems according to Turber et al. They argue that organizations are therefore required to rethink their firm-centered lenses in order to stay ahead in IoT driven market environments. There is however great difficulty associated when trying to capture and tap into the unprecedented ecosystem complexity around products and services in a structured way. Turber et al. identifies a major gap in business model research addressing Burkhardt's et al.'s (2011) identification of the *"absence of formalized means of representations (...) to allow a structured visualization of business model"* (Turber et al., 2014:18). To test traditional business model theory on IoT businesses Turber et al. *"applied existing methods for business modeling in workshops with companies, and found that the important characteristics of IoT ecosystem cannot sufficiently be addressed by these methods. Such characteristics, for instance, include multi-partner collaborations on digital platforms or the customers enhanced role as value co-creator by providing user data"* (ibid.).

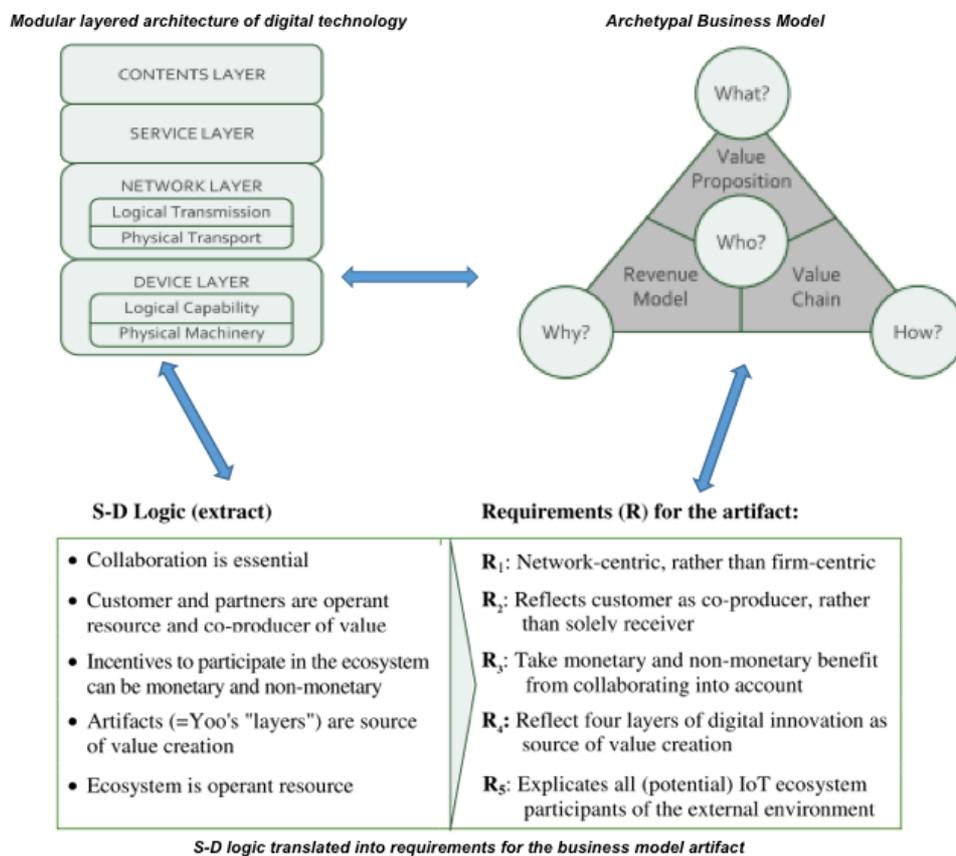
Turber et al.'s research therefore addresses the need for a business model framework in IoT-driven market environments, which recognizes the specific impact of digitization, for this they use a design science research (DSR) approach to create a new artifact, which is described as business model framework for the Internet of Things. The design of the artifact's requirements is build upon sources of justificatory knowledge across different domains, including marketing, strategic management and information systems. The business model framework, all in all, should provide researchers with a framework to readily analyze business models in complex, IoT driven ecosystems. Turber et al. furthermore argue that they provide practitioners with an understandable and consistent framework to depict their organization's current and envisioned business models within complex IoT ecosystems with their artifact (ibid.).

The DSR approach Turber et al. takes is an approach for visualizing, envisioning and analyzing complex business models in digital market environments. The method includes six iterative activities, their overall

process can be seen in Appendix D. Turber et al. build their artifact upon relevant, extent work, which they found in three domains:

- **Information Systems (IS)** research provided Turber et al. with essential insights regarding the nature of digital technology and digitized objects.
- **Service-dominant (S-D) logic** as part of recent marketing research provided them with a valuable extract about new market dynamics in the light of increasing digitization.
- **Business Model (BM)** research provided them with insights into useful building blocks by a large number of previous modeling approaches for different purposes.

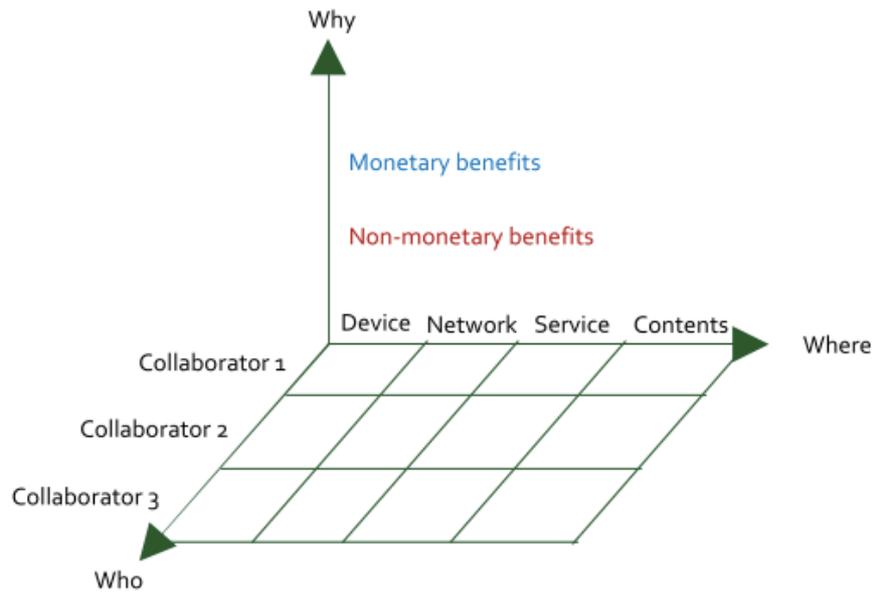
Turber et al. uses three models to build the requirements for their artifact as seen in figure 3.4, which they identified through their research of IS, S-D and BM.



**Figure 3.4: The building stones for Turber et al.'s artifact**

After several iterations along the path of the six activities, Turber et al.'s (2014) research led to a network-centric, 3-D framework consisting of three dimensions as seen in figure 3.5 (ibid.:24).:

- **Who:** Collaborating partners who build the value network
- **Where:** Source of value co-creation rooted in the layer model of digitized objects
- **Why:** Benefits for partners from collaborating within the value network



*Figure 3.5: Artifact – framework design for a business model framework in the IoT context (Turber et al., 2014:25)*

### **The “Who” Dimension: Value Network of Collaborators**

“Who”, which is the first dimension encompasses all participants of an IoT ecosystem circling around digitized products. These include partners, customers, and all remaining stakeholders, which Turber et al. (2014:25) refer to as “collaborators” in a wider sense and are listed one by one. They are specified at the intended level of abstraction. The rationale behind this dimension is that the explicit itemizing of all participants reflects the service-dominant logic’s view<sup>5</sup>, which is that a company’s external environment represents an “operant resource”, which offers the inherent opportunity for each participant to co-create value with other external participants as collaborators (ibid.). According to Turber et al. (2014) customers are listed together with other collaborators on a single dimension, which conveys the philosophy, that value is always co-created with the customer, and often even co-produced, particularly in the digital context. They therefore do not distinguish between partners and customers, which are all part of the “Who” dimension (ibid.).

### **The “Where” Dimension: Sources of Value Creation**

The four-layered modular architecture of digitized products<sup>6</sup> represents the “Where” dimension. This dimension includes the devices, connectivity, services and contents layer. The different layers each represent a distinct source of opportunities for collaborators to contribute to the value creation process (Turber et al., 2014:26). The collaborators are naturally structured in the layers according to their contribution in the value creation process. Turber et al. (2014) furthermore highlights that the four layers are able to depict “co-

<sup>5</sup> See figure 4.4 under the S-D logic translate into requirements for the business model artifact model

<sup>6</sup> See figure 4.4 under the modular layered architecture of digital technology model

opetition” aspects within the ecosystem landscape, as two partners can be partners at one layer and compete on another layer within the same ecosystem (ibid.).

**The “Why” dimension: Benefit for Collaborators**

Each collaborator’s “reason” to participate in the ecosystem is outlined in the “Why” dimension. This dimension is meant to depict all monetary as well as non-monetary benefits, which attracts collaborators to participate in the ecosystem (Tuber et al., 2014:26). According to Turber et al. it is vital to, not only depict one company’s revenue model, which “Why” is usually meant for, but to consider all collaborators’ benefit in a broader sense from their participation in the ecosystem (ibid.:27). This is due to the fact that the collaborators in sum build the external ecosystem, and in consequence a healthy ecosystem features a competitive advantage, where the overall stability depends on each collaborator’s satisfaction. It is furthermore not necessary to feature a customer-specific value proposition, as in traditional business models “What”, as the customer is likewise regarded as collaborator in Turber et al.’s framework, and can therefore be covered in the same dimension “Why”, as this outlines all benefits occurring in the ecosystem. These benefits can as mentioned be monetary or non-monetary (fun, ethic reasons, etc.) (ibid.).

Together these three dimensions make up the framework proposed by Tuber et al. (2014). This new artifact should be a useful and an effective solution to the problem of depicting IoT-driven business models. To assess their framework Turber et al. conducted evaluation on two levels: they evaluated (1) the artifact as research output and (2) the underlying research process. With the outcome from this they created a table showing the criteria and method to evaluate the artifact’s performance, as seen in table 3.3 (ibid.:27, 28)

*Table 3.3: Criteria and method to evaluate the artifact’s performance (Turber et al., 2014:28)*

Goal of our DSR study	Criteria sets based on goal	Methods for gathering evidence
An effective solution...	<b>Set 1 Good model properties</b> M <sub>1</sub> : Fidelity with the real world M <sub>2</sub> : Completeness (=R <sub>1</sub> -R <sub>6</sub> ) M <sub>3</sub> : Level of detail M <sub>4</sub> : Robustness	Interviews / expert evaluation multiple case studies, action research, instantiation
...which is able to depict business models in IoT environments	<b>Set 2 Justified solution requirements</b> R <sub>1</sub> : Network-centric view R <sub>2</sub> : Customer as co-producer R <sub>3</sub> : (Non-) monetary reasons to participate R <sub>4</sub> : Value creation across four layers R <sub>5</sub> : Ecosystem as operant resource	

Turber et al. (2014) conclude that their DSR study at its completion represents a business model framework, which contributes to both theory and practice. In the theoretical sense their work adds to the current business model research in the emerging context of IoT by providing a both theoretically founded and field-tested business model framework. With the artifact researchers can for example readily use the framework to analyze IoT business model patterns in an efficient and structured way. In the practical sense

the artifact serves as a tool for depicting, analyzing and envisioning business models in IoT. The artifact can furthermore decidedly support business model development in complex IoT ecosystems. This is due to the fact that it makes recent IoT-driven market dynamics explicit, while specifying digitalized goods. This is highly relevant according to Turber et al., as without a clear view on market dynamics and collaborative value creation logic, it can be hard to create sustainable IoT ecosystems and be a competitive part of it. This is the situation for many companies today according to Turber et al. (2014).

### 3.2.2.1 Critical review on Turber et al.'s artifact

Turber et al.'s article highlights the fact that an IoT business model should be seen from an ecosystem perspective, to respond to the changed dynamics, where the ecosystem is an operant resource. To gain insights into the dynamics and digitization of IoT Turber et al. uses theories and concepts from IS, S-D logic and business models. Their artifact seeks to answer who the collaborators are throughout the ecosystem, where value is created and from which channel, and why the company and all collaborators participate in the ecosystem in the sense of benefits, as seen in table 3.4. The artifact does not distinguish between the organization, industry or ecosystem, but seeks to include all perspective at once.

*Table 3.4: Focus and aim of Turber et al.'s Network-centric IoT business model*

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>	- Collaborators (customers, partners, coopetition, stakeholders)	- Collaborators (customers, partners, coopetition, stakeholders) ?	- Collaborators (customers, partners, coopetition, stakeholders)
<b>What?</b>			
<b>When?</b>			
<b>Where?</b>	- Where in the four-layered architecture of digitized products? (device, connectivity, services and content layer)	- Where in the four-layered architecture of digitized products? (device, connectivity, services and content layer) ?	- Where in the four-layered architecture of digitized products? (device, connectivity, services and content layer)
<b>Why?</b>	- Why does the company participate in the ecosystem? - Why does each collaborator participate in the ecosystem? (monetary and non-monetary benefits)	- Why does each collaborator participate in the ecosystem? (monetary and non-monetary benefits)	- Why does each collaborator participate in the ecosystem? (monetary and non-monetary benefits)
<b>How?</b>			

As the model itself does not distinguish from the three levels of the IoT value chain it can make it difficult to get a clear understanding on where the value is created and captured, and which channels are used. This information would in turn be able to highlight more potential collaborations across industries and throughout the ecosystem. Furthermore, the model does not include the what and when perspective, and I therefore argue that it is not comprehensive enough to depict an IoT business extensively, as many essential insights will get lost in this simplification. Much of the rationale behind Turber et al.'s artifact is very well formed and evaluated, and contributes to many important insights into the IoT business model concept. But overall the framework focuses very little on value processes in-depth, and can result in a superficial overview, if the

framework is not utilized correctly. The framework for example views customers as co-producers of value, which is an important insight, however the quality of contribution from customers can vary, depending on which level at the IoT value chain they are, and which types of adopters they are. I therefore argue that distinguishing between the IoT value chain levels can contribute to more in-depth insights into the ecosystem. Turber et al. uses the case of “Nest” to illustrate the use of the framework, which provides a very good overview on how the framework should be used, the model does however lack the visual insight many business models seek to contribute to, e.g. the business model canvas.

Overall the model expands further from the traditional business model thinking than Sun et al.’s model, and succeeds to include the different layers of digital technology included in the IoT phenomenon, as well as incorporate a network-centric view, which in turn reflects a multi-partner collaboration, thereby also taking the complex ecosystem perspective view into the model. Turber et al.’s overall research and arguments highly contributed to the outcome of the thesis, as it gave essential insights into the digitalized and networked environment. The model itself however, falls short to give a comprehensive overview for an organization wanting to analyze the business processes and gain insight into value creation and capture in the overall IoT ecosystem, and to analyze to which extend the organization plays a role in the ecosystem.

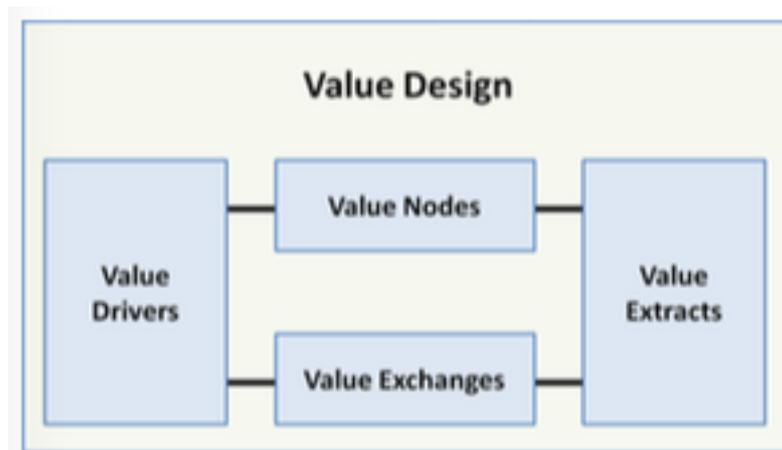
### **3.2.3 IoT Business Model as a Value Design Tool (Westerlund et al., 2014)**

Westerlund et al. (2014) proposes a value design concept when researching business models in the IoT ecosystem. They argue that the traditional view on business models fail to explain the dynamics between the components, or “*how the engine works*” much like Turber et al.’s argument. The value design therefore focuses on the action instead of the parts of the ecosystem, which builds on different value flows and aspects in the IoT ecosystem (Westerlund et al., 2014:9, 10).

Westerlund et al. highlight the many pitfalls of making money in the IoT, as previous research in nearly silent of the challenges related to monetizing the IoT. The challenges include issues with identifying horizontal needs and opportunities, the managerial challenges related to internal team alignment, and ways to overcome the market maturity problems for novel IoT technology. Westerlund et al. extend this view and identify three contemporary challenges of the IoT, namely, comprising the diversity of objects, the immaturity of innovation and the unstructured ecosystem. The identified challenges are based on a literature review and discussions with experts on the IoT performed by Westerlund et al. They argue that these challenges focus on platform, developer community, and business ecosystem spheres of the formation of IoT-based ecosystem business models.

Westerlund et al. emphasize that the term *ecosystem business model* has at least three interpretations in the literature. The term can firstly refer to a business model with specific properties, like a business anchored in ecosystem concepts (e.g. the concept of a “green business model”, which appeals to ecologically-motivated stakeholders and has specific “green” qualities). Second, an ecosystem business model (or category of

business models) can be shared by participants of an ecosystem (e.g. the term “fabless semiconductor business model”, that implies that all semiconductor firms are more or less the same). Lastly, it can refer to construct at a level of analysis above the firm that explains how the entire ecosystem works towards common goals rather than how the firm-level business works. Westerlund et al. highlight that the third interpretation however, usually refers to the ecosystem structure and mechanisms rather than focusing on the ecosystem as a business model. Rather than understanding these various interpretations as distinct concept, Westerlund et al. research views them as different views of the same phenomenon, and argue that an ecosystem business model is composed of a set of value pillars anchored in ecosystems, which focus on both the firm’s method of creating and capturing value as well as any part of the ecosystem’s methods of creating and capturing value to the ecosystem. Westerlund et al. provide a value design tool, as seen in figure 3.6, which they argue can assist managers overcome the mentioned challenges, and be able to design feasible business models for the IoT. The tool assist companies focus on an ecosystem approach of doing business and consider the ecosystem nature of the IoT rather than emphasize an individual company’s self-centered objectives.



**Figure 3.6: Key pillars in the value design tool for the IoT ecosystem (Westerlund et al., 2014:11)**

Figure 3.6 shows the four pillars in Westerlund et al.’s (2014) value design framework. Westerlund et al. (2014) emphasize that relevant business model literature shares the view that the business models are about value creation and value capture, and argue that managers can design viable IoT business models by taking into consideration a variety of aspects related to these two essential value task. Here they refer to the components in their value design tool, which components are further elaborated below.

### **Value Drivers**

There are different *Value drivers* in the ecosystem. These value drivers comprise both individual and shared motivations of diverse participants. They promote the birth of an ecosystem to fulfill a need to generate value, realize innovation and make money. Westerlund et al. (2014:10) argue, “*that a focus on shared value drivers is crucial to create a non-biased, win-win ecosystem.*” The value drivers most respect the objectives of other actors to build a long-term relationship. It is important, however, that separate value drivers also serve as individual value node’s motivational factors. Examples of value drivers that different

actors may share in an IoT ecosystem are sustainability, cyber security, and improved customer experience (ibid.).

### **Value Nodes**

*Value nodes* include various actors, activities, or (automated) processes that are linked with other nodes to create value. These nodes may include autonomous actors, such as smart sensors, pre-programmed machines, and linked intelligence. There is a significant heterogeneity of value nodes in the IoT ecosystem, as the ecosystem is a compound of different value nodes. In addition to single activities, automated services, and processes, individuals, or commercial or non-profit organizations, these value nodes may be groups of such organizations, networks of organizations, or even groups of networks (ibid.).

### **Value Exchanges**

*Value exchanges* is an exchange of value by different means, resources, knowledge, and information. The exchange of value occurs between and within different value nodes in the ecosystem, which are described by different value flows that can be tangible and intangible. The flows show “how the engine works” by exchanging by different means resources, knowledge, money, and information. Value exchanges can therefore be said to describe the actions that takes places in the business ecosystem in order to create and capture value, and are crucial, as they also specify how revenues are generated and distributed in the ecosystem (ibid.).

### **Value Extract**

The last component of the value design is *value extract*, which is the part of the ecosystem that extracts value. It shows the meaningful value that can be monetized and the relevant nodes and exchanges that are required for value creation and capture. The concept of value extracts is useful because it can help to focus on a relevant portion of the ecosystem, as it can for example help a manager “zoom in” and “zoom out” of the ecosystem to focus on something that is beneficial from a business perspective. Value extract is furthermore useful when defining the core value and its underlying aspects in the ecosystem (Westerlund et al., 2014:10).

### **Value Design**

In short the value design illustrates how value is deliberately created and captured in the ecosystem. Figure 3.2 illustrates how the components in the value design influence and affect each other. Westerlund et al. (2014) value design is an overall architecture that maps the foundational structure of the ecosystem business model. It provides the boundaries for the ecosystem on one hand, while describing the whole entity that creates and captures value, and on the other hand it is the sum of the four value pillars and results in a pattern of operation (Westerlund et al., 2014:10). In figure 3.2 I have gone beyond the four value pillars of Westerlund et al.’s (2014) value design and linked the four pillars to the IoT ecosystem. When researching

the IoT ecosystem health it is necessary to look at the levels of competitiveness, productivity and entrepreneurship, as this can be a significant source of sustainable economic growth, this can be categorized as the *state of the ecosystem*, as seen in figure 3.2. The impact on the ecosystems micro and macro levels therefore depends on the effective interaction of the actors in the ecosystems natural environment (Pilinkiene & Mačiulis, 2014:369). The stronger the ecosystems health is, the faster the ecosystem will evolve, which is illustrated as the *ecosystem net increase* in the figure.

### **3.2.3.1 A critical review on Westerlund et al.'s value design tool**

Westerlund et al.'s framework focuses on the action instead of the parts, and like Turber et al. seeks to explain the dynamics between the components in the IoT ecosystem, or “how the engine works”. Between the three frameworks Westerlund et al. includes traditional business model thinking the least into their framework, and merely highlights the importance on moving from a firm-centric view to an ecosystem view when developing an IoT business model. Westerlund et al. identify three contemporary challenges of the IoT, namely, comprising the diversity of objects, the immaturity of innovation and the unstructured ecosystem. Their model provides insight into how value is created and captured throughout the ecosystem. The value design tool is an overall architecture that maps the foundational structure of the ecosystem business model. It provides boundaries for the ecosystem on one hand, and describes the whole entity that creates and captures value. And on the other hand, it is a sum of four value pillars and results in a pattern of operations, and in that vein, value design is a concept that is quite similar to the concept of business models. The difference between the two are however, that business model is typically associated with the business model of a firm, whereas the value design can be defined to apply at the ecosystem level. Westerlund et al.'s value design seeks to identify the questions shown in table 3.5.

*Table 3.5: Focus and aim of Westerlund et al.'s value design tool*

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>	- Who are the actors? (include autonomous actors, such as smart sensors, pre-programmed machines)	- Who are the actors? (include autonomous actors, such as smart sensors, pre-programmed machines)	- Who are the actors in the ecosystem? (include autonomous actors, such as smart sensors, pre-programmed machines)
<b>What?</b>	- What channels? - What technologies (devices, sensors, machines)? - What activities and by what means? - What value can be monetized?	- What channels? - What technologies (devices, sensors, machines)? - What activities and by what means? - What value can be monetized?	- What channels? - What technologies (devices, sensors, machines)? - What activities and by what means? - What value can be monetized?
<b>When?</b>			
<b>Where?</b>	- Where are the value exchanges, which channels? -	- Where are the value exchanges, which channels?	- Where are the value exchanges, which channels?
<b>Why?</b>	- What are the value drivers and motivation of the individual? -	- What are the value drivers and motivation of the diverse participants?	- What are the value drivers and motivation of the diverse participants?
<b>How?</b>	- How is value extracted? - How is value created and captured? - How is revenue generated and distributed in the ecosystem?	- How is value extracted? - How is value created and captured? - How is revenue generated and distributed in the ecosystem?	- How is value extracted? - How is value created and captured? - How is revenue generated and distributed in the ecosystem?

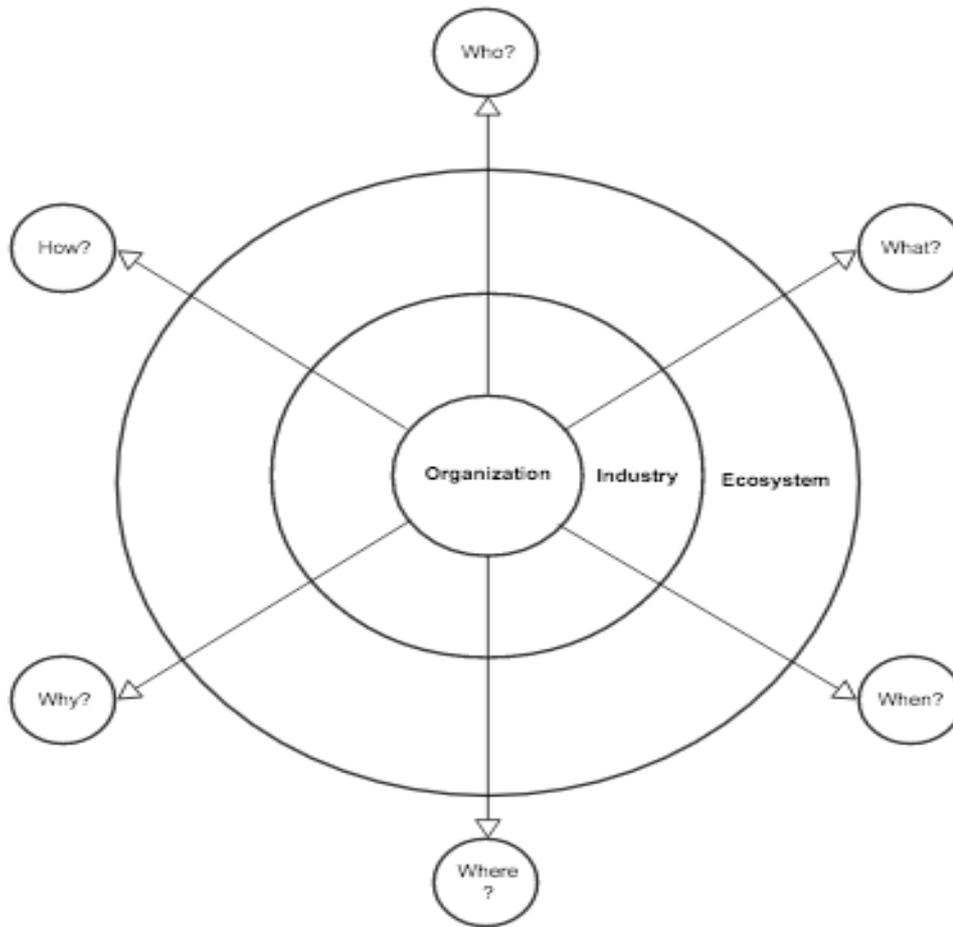
Of the three frameworks Westerlund et al.'s focuses the most on the value activities in the ecosystem. The value design tool can be used across the organization, industry and ecosystem, but mostly focuses on the value creation and capture activities in the overall ecosystem. The value design tool framework contributes to essential aspects in the thesis, and my framework includes many of the value creation and capture activities and processes as taken from the design tool. The logic behind the framework is highly relevant and contributes to a good foundation for when developing an IoT business model framework, which is also the intention of Westerlund et al.

Westerlund et al. highlight the need for future research, which verifies the four value pillars and apply them into practice in order to develop the tool. They furthermore call for more research on business model frameworks in the emerging IoT context, as this is a fruitful field for developing a design tool for ecosystem business models. Westerlund et al. provides a great framework for researching many aspects of the IoT value chain, however the framework is mostly a tool researchers and practitioners can use to highlight different value flows and activities, for than to create a more extensive business model framework, where these flows and activities are illustrated, much like the framework I propose. In the thesis I have therefore also sought to use this framework as so, as many essential flows and activities are identified in this paper. Overall the tool

provides a great initial research for the value processes in the overall ecosystem, and can be used to identify further essential components.

### 3.3 Business Model Framework for IoT

Based on the comprehensive research on IoT from a business perspective and the analysis of the three earlier proposed IoT business model frameworks I have been able to identify many essential aspects which needs to be taken into consideration when researching a possible IoT business model framework. In the research process I identified the three levels of the IoT value chain, namely the organization, industry and ecosystem, which are all essential to review when developing an IoT business model. Furthermore, I identified necessary criterions a possible IoT business model framework should be able to answer or at least take into consideration throughout the process of either analyzing the businesses state in the IoT ecosystem today, or how the business will value from joining the IoT ecosystem in the future. From these findings I was able to produce an IoT business model, which incorporated all these and linked them together. Other criterions to the model was it should be able to illustrate the complexity of the synergies and dynamics of IoT in a simple and understandable manner, it should furthermore include the flexibility needed to view the IoT ecosystem from different stages of innovation and adoption to innovation. The proposed IoT business model can be seen in figure 3.7. As seen the Who? What? When? Where? Why? And How? Should be taken into consideration on all levels of the IoT value chain.



**Figure 3.7: Proposed IoT business model framework**

However, in an initial first stage before utilizing the model it is important that the business understands the different strategies in the ecosystem, Enabler, Engager and Enhancer, and which initial strategy the business itself can identify with. From here the business can analyze, which of the other strategies and participants it interacts with, and at which levels; the industry or the ecosystem. This will make it easier for the business to identify future collaboration and competition partners in the ecosystem. Table 3.6 is an extension to table 2.2, as this table furthermore includes what these strategies can contribute to. The limit of contribution is however, only set by the business itself, as the opportunities and collaboration prospects are unlimited in the IoT ecosystem, where the only barrier is ones' imagination.

*Table 3.6: Enabler, Engagers & Enhancer characteristics and contribution*

<b>Category</b>	<b>Characteristics:</b>	<b>Contributes with:</b>
<b><i>Enabler</i></b>	<ul style="list-style-type: none"> <li>• Plays well with others,</li> <li>• Friendly and flexible</li> <li>• B2B and technology orientated</li> <li>• Builds and maintains the IoT infrastructure for engagers.</li> </ul>	<ul style="list-style-type: none"> <li>• The technology</li> <li>• Cloud services</li> <li>• Platforms</li> <li>• Data warehouse systems</li> <li>• Services for the engagers</li> </ul>
<b><i>Engager</i></b>	<ul style="list-style-type: none"> <li>• Creative, genius and bold</li> <li>• Use service from enablers to produce to end-users</li> <li>• Direct link between IoT and market</li> <li>• Sell disruptive products</li> <li>• Not a 'traditional' tech company</li> <li>• Understands how to gain insight</li> </ul>	<ul style="list-style-type: none"> <li>• Disruptive products</li> <li>• A direct link to customers</li> <li>• Gaining insights</li> <li>• Producing valuable report</li> <li>• Customer insights</li> <li>• Build on services</li> <li>• Cooperation between industries and ecosystems</li> </ul>
<b><i>Enhancer</i></b>	<ul style="list-style-type: none"> <li>• Provides integrated services that reframe and repackage products and services from engagers,</li> <li>• Perceptive, smart and reliable</li> <li>• Finds new ways to engage with customers</li> <li>• Find new ways to create and extract value</li> <li>• Find new ways to make useful connections</li> </ul>	<ul style="list-style-type: none"> <li>• Reframed and repackaged products and services from the insights of engagers</li> <li>• Innovative services</li> <li>• Create and extract value</li> <li>• Provide useful connections between enhancers and engagers</li> </ul>

When the business has identified and understood the strategy they have in the IoT ecosystem they can use table 3.7 to analyze their (future) IoT business prospects. In the table below are examples of questions illustrated, which the business can seek to identify for analyzing all value flows and activities, as well as possible risk associated, and when the time is right to expand, renew or simply just join the IoT ecosystem or other IoT ecosystems. All aspects of flows, activities, actors, risk and barriers, should be identified throughout the IoT value chain. Next I will explore the meaning of viewing these aspects from the different IoT value chain levels.

**Table 3.7: Example of questions for the IoT business model framework throughout the value chain**

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>	<ul style="list-style-type: none"> <li>- What skillset does the employees possess?</li> <li>- Who are the company's main stakeholders? (customers, partners, suppliers, vendors)</li> </ul>	<ul style="list-style-type: none"> <li>- Who are the main stakeholders?</li> <li>- Key partners</li> <li>- Competition</li> <li>- Are there any levels of coopetition?</li> </ul>	<ul style="list-style-type: none"> <li>- Who is the ecosystem leader(s)?</li> <li>- Who are potential new customers?</li> <li>- Potential new partners</li> <li>- Potential new competition/coopetition</li> </ul>
<b>What?</b>	<ul style="list-style-type: none"> <li>- What are the key channels?</li> <li>- Key resources</li> <li>- Cost structure</li> <li>- Value proposition</li> <li>- Value drivers</li> <li>- Needs</li> <li>- Links</li> <li>- Value exchanges/ value extracts</li> <li>- Flows</li> <li>- core value</li> <li>- What are other relevant activities?</li> <li>- Risk</li> <li>- State of the ecosystem</li> </ul>	<ul style="list-style-type: none"> <li>- What are the key channels?</li> <li>- Key resources</li> <li>- Cost structure</li> <li>- Value proposition</li> <li>- Value drivers</li> <li>- Needs</li> <li>- Links</li> <li>- Value exchanges/ value extracts</li> <li>- Flows</li> <li>- core value</li> <li>- What are other relevant activities?</li> <li>- Risk</li> <li>- State of the ecosystem</li> </ul>	<ul style="list-style-type: none"> <li>- What are the key channels?</li> <li>- Key resources</li> <li>- Cost structure</li> <li>- Value proposition</li> <li>- Value drivers</li> <li>- Needs</li> <li>- Links</li> <li>- Value exchanges/ value extracts</li> <li>- Flows</li> <li>- core value</li> <li>- What are other relevant activities?</li> <li>- Risk</li> <li>- State of the ecosystem</li> </ul>
<b>When?</b>	<ul style="list-style-type: none"> <li>- When should the company evolve towards IoT? (after analyzing the who and what)</li> <li>- When will the company's stakeholders adopt new innovation?</li> </ul>	<ul style="list-style-type: none"> <li>- When did/will the company's stakeholders move towards IoT?</li> <li>- When will the company's stakeholders adopt new innovation?</li> </ul>	<ul style="list-style-type: none"> <li>- When should the company expand in the ecosystem? (move towards new markets)</li> <li>- When will the company's stakeholders adopt new innovation?</li> </ul>
<b>Where?</b>	<ul style="list-style-type: none"> <li>- Where is the company in the IoT ecosystem?</li> <li>- Where are the value creation/capture processes?</li> <li>- Where are the value exchanges?</li> <li>- Where are the information flows?</li> </ul>	<ul style="list-style-type: none"> <li>- Where is the industry in the IoT ecosystem?</li> <li>- Where are the partners/competitors?</li> <li>- Where are sources of opportunities in the industry?</li> <li>- Where are the value creation/capture processes?</li> <li>- Where are the value exchanges?</li> <li>- Where are the information flows?</li> </ul>	<ul style="list-style-type: none"> <li>- Where is the IoT ecosystem the company is part of compared to the overall IoT environment?</li> <li>- Where are the (potential) partners/competitors?</li> <li>- Where are the potential customers?</li> <li>- Where are the value creation/capture processes?</li> <li>- Where are the value exchanges?</li> <li>- Where are the information flows?</li> </ul>
<b>Why?</b>	<ul style="list-style-type: none"> <li>- What are the monetary/non-monetary benefits?</li> <li>- Why should the company expand to new markets (if the when fits)?</li> </ul>	<ul style="list-style-type: none"> <li>- What benefits are involved for other actors in the industry?</li> <li>- What are the monetary/non-monetary benefits?</li> </ul>	<ul style="list-style-type: none"> <li>- What benefits are involved for other actors in the ecosystem?</li> <li>- What are the monetary/non-monetary benefits?</li> </ul>
<b>How?</b>	<ul style="list-style-type: none"> <li>- How is knowledge/ information exchanged throughout the company?</li> <li>- How do the flows/ activities work?</li> <li>- How does the system work?</li> <li>- How is value created and captured?</li> <li>- How is value exchanged/ extracted?</li> <li>- How is the ecosystem structured/unstructured?</li> </ul>	<ul style="list-style-type: none"> <li>- How is knowledge/ information exchanged throughout the industry?</li> <li>- How do the flows/ activities work?</li> <li>- How does the system work?</li> <li>- How is value created and captured?</li> <li>- How is value exchanged/ extracted?</li> <li>- How is the ecosystem structured/unstructured?</li> </ul>	<ul style="list-style-type: none"> <li>- How is knowledge/ information exchanged throughout the ecosystem?</li> <li>- How do the flows/ activities work?</li> <li>- How does the system work?</li> <li>- How is value created and captured?</li> <li>- How is value exchanged/ extracted?</li> <li>- How is the ecosystem structured/unstructured?</li> </ul>

### **3.3.1 Organizational Level**

On the organizational level, which represent the micro level, the company must seek to understand the resources and capabilities available. It should also understand its role in the IoT ecosystem, depending on what IoT strategy they belong to; Enabler, Engager or Enhancer. A company's competitive advantage relies on creating more value than its competitors, this however requires innovation, and therefore the value creation of the individual companies depends on its ability to innovate. For some companies it will contribute to innovative success when applying IoT technology into their products and services, while for others it will create a negative affect, like in the case of Target. If a company's customers and main stakeholders are not able to adopt the IoT approaches the company have integrated, this will result in a costly lost for the company. Most importantly for traditional companies who are not born in the digital environment, is understanding the risk associated with moving to the IoT ecosystem to early or too late. As the concept of IoT will disrupt almost every sector and industry, if not all, traditional businesses must have an IoT strategy plan if they want to prevent becoming obsolete when this disruptive wave hits. A comprehensive analysis of the business is therefore needed, even if the business is already present in the IoT ecosystem. In such a dynamic and innovative environment IoT brings, businesses must be able to foresee the next big wave before it hits, as this in some cases could hurt businesses if they are not prepared, but with the right strategy a big wave can also contribute in a positive way for the business, who is more innovative than its competitors. It is up to the individual business and company to use these synergies and dynamics to their advantage, by always staying a step ahead.

### **3.3.2 Industry Level**

In the industry or sector level the IoT brings new collaborations, which surpasses those from traditional businesses. It is therefore essential for companies to understand their sector and industry level, and which players are already or planning to move towards the IoT ecosystem. In many industries a first-mover role can be challenging, and may even cause a negative affect on the business itself, or in the industry perspective. The pace of innovation has never moved faster than today, and what seems to first be ready in five years, can quickly become mature within a year. Companies and industries can no longer plan for five years ahead and think that the dynamic environment will look the same as what they though it would five years ago. Innovation gives birth to innovation and this trend is quickly spreading. Companies born in the cloud have the benefit of agility and flexibility, and soon whole industries will become part of this trend. If the industry a company is part of is either moving to fast or to slow, it is time to consider a renewal and strategy change. Ones' industry and sector can play a huge role in the success of the company's IoT strategy and role in the IoT ecosystem. An extensive analysis of ones' industry is therefore essential for the company's IoT strategy to payoff and produce value. By understanding the industry level and the different collaborators connected to the company, it is easier to identify value activities and flows, as well as follow these to see if they produce

the expected value. Some collaborations may never pay off, and instead end in damaging affects for the company. The state of the industry in the overall ecosystem is therefore highly relevant to review.

### **3.3.3 Ecosystem Level**

Lastly the company must understand the overall ecosystem they are part of. A business can be part of multiple IoT ecosystems, and use these ecosystems differently or equally to benefit from it. By understanding which ecosystem(s) the company is part of, and which other key player are involved in the same ecosystem, the company can gain greater insight into the ecosystem and their own role. It is very important that there is a clearly defined structure and governance, stakeholder roles and value-creating logics in the ecosystem, so that it does not become unstructured. Other challenges for ecosystems are lack of appropriate or required participants in an emerging ecosystem, as it is important to remember that customers have a tendency to join those ecosystems with most players, as they in turn contribute to more products and services. If a company wishes to pursue new business opportunities, they most open new relationships in new industries, or extending existing relationships, which takes time and is challenging for companies. The complexity of an ecosystem is associated with the number of participants, and an early ecosystem is an unstructured, chaotic, and open playground for participants. As IoT is still in the process of maturing, like the Internet once was, there is a need for the emergence of keystones that will reshape the IoT business ecosystem, which can be done by well defined IoT business model frameworks. Before moving towards a (new) IoT ecosystem the company must first analyze the underlying synergies and dynamics, which will in turn play a huge role for the company if they decide to move forward. The analysis of the ecosystem is in some ways the most important stage, as this gives a clear indicator for which ecosystem the company should become part of, according to the ecosystems state and potential.

## Chapter 4 – Framework illustration

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In this chapter I will illustrate the IoT business model and its components by discussing the experience of New Orleans implementation of an IoT solution from Microsoft and Motorola Solution for administering emergency calls for the city of New Orleans, Louisiana. This case is chosen to illustrate how IoT can disrupt and affect industries and areas not previously connected with complex technology and IT solutions. It is not a stereo typical business case, as it is not an actual business. A case like this can however play a big part for the further development of an IoT ecosystem, as it brings with it future needs and services and overall great value to the ecosystem. The case furthermore gives an understanding for how many unlikely areas can benefit from the IoT ecosystem, as well as illustrate the IoT business models flexibility and usability.

### 4.1 A Future-Ready Platform for 911 Calls in New Orleans

Orleans Parish Communication District (OPCD) serves approximately 350.000 residents and handles more than 1 million calls annually, routing request to police, fire and emergency medical services (EMS) personnel in the field. The OPCD equipment fields calls to 16 police, four fire and three EMS dispatch positions that provide coverage for the city. When a call comes in to 911, seconds count, and the ability to provide an efficient, coordinated response and arm police officers and emergency personnel with critical information can help avert disaster and save lives. OPCD therefore wanted to respond better and faster to incidents by improving the flow of data between multiple agencies. For this OPCD implemented Motorola Solutions PremierOne CAD and integrated call control based on Microsoft technology including embedded versions of Windows Server and Microsoft SQL Server. The solution draws on the potential of the IoT to vastly streamline the ways in which 911 dispatchers communicate with officers and first responders. The solution connects formerly disparate police, fire and medical services applications, a 911 call system, mobile terminals, tablets, and a data warehouse into one intelligent system. It uses a powerful blend of server and database technology, modern applications and multimedia data and creates insight that helps emergency personnel make quicker and smarter decisions. The new system builds on devices and datasets that already exist, and helps the OPCD transform emergency service, shorten response times, improve safety and eliminate error-prone manual processes.

OPCD needed a way to easily handle multiple types of data too, including structured database files and unstructured information such as text messages, and to do so through one streamlined interface, helping dispatchers save critical seconds when they are needed most. The solution provided by Motorola and based on Microsoft technology went live in September 2013. It integrates 911 telecommunications and applications from the EMS, police and fire departments in central console, the system includes a data warehouse running on Windows server for Embedded Systems<sup>7</sup> and Microsoft SQL Server for Embedded Systems<sup>8</sup> software

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<sup>7</sup> <http://www.microsoft.com/windowseembedded/en-us/windows-server-2012-for-embedded-systems.aspx>

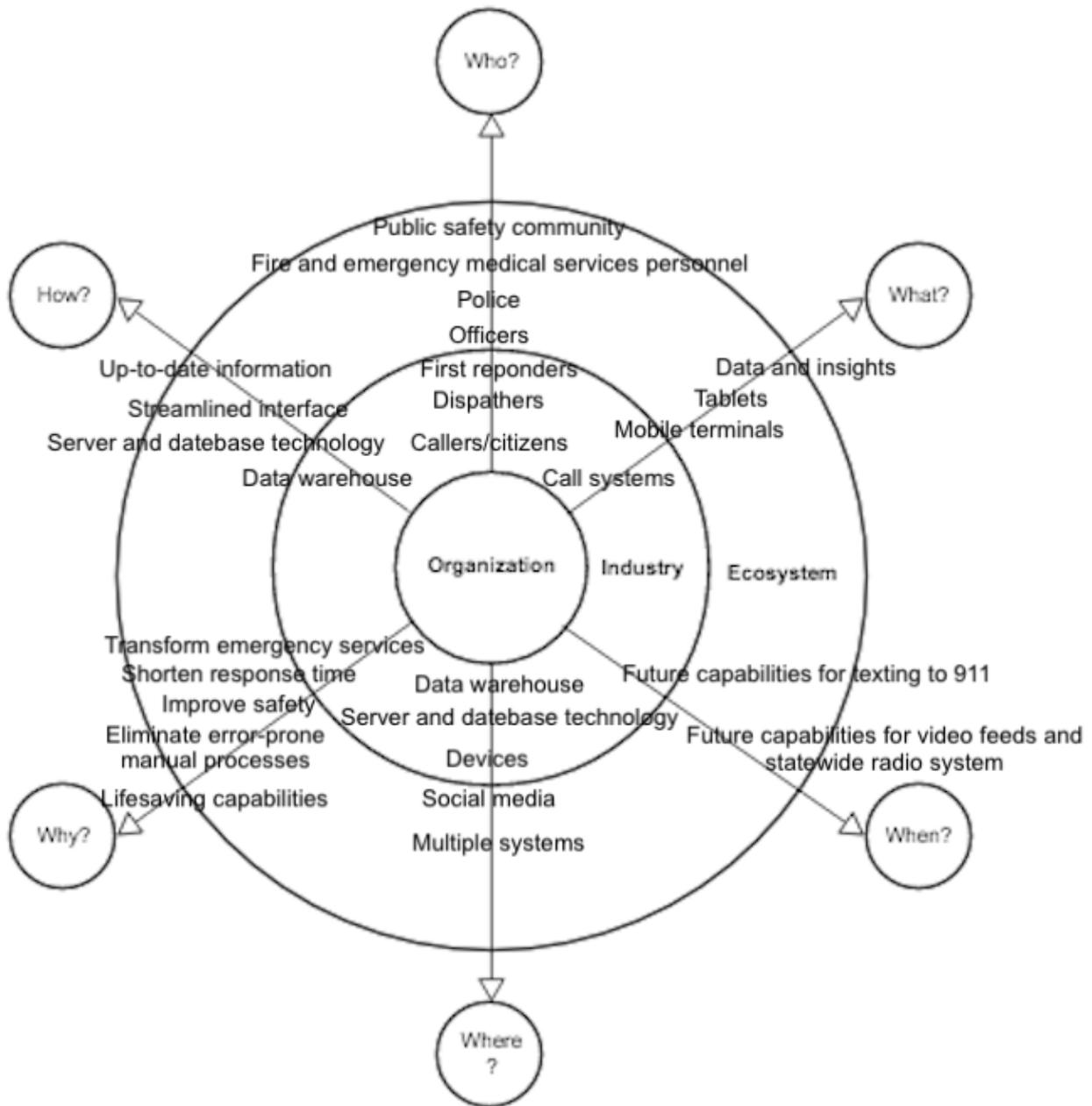
<sup>8</sup> <http://www.microsoft.com/windowseembedded/en-us/microsoft-sql-server-2014-for-embedded-systems.aspx>

with a service oriented architecture based on the Microsoft .NET Framework<sup>9</sup>. The solution also uses SQL Server 2012 Reporting Services to share information within the public safety community.

Having better access to more meaningful data through the new system saves time and provides better information to responders. The system automatically routes calls to the appropriate dispatcher and alerts the closest emergency personnel, who see the incoming information in real time. There is a set of rules built into the system that identified the type of call, the locations, and the personnel and resources required. If the call is for example routed to the fire department the system determines the closest station with available equipment and manpower. Drawing on multiple systems, calls are also cross-referenced with historical data and a mapping system, which is used to notify dispatchers and responders of prior incidents at an address, or involving a person. Dispatchers have access to an array of information, and multiple calls about the same incident are automatically synchronized and aggregated into a single report. In the same way, the solution's data warehouse also pushes this rich, supplemental information through the city of New Orleans' local area network (LAN) to tablet used by paramedics, and to the mobile terminals used by police units sent to stabilize a scene. Officers can indicate if the scene is safe, or if they need immediate help, with one touch. When an emergency calls comes in the call have already gone out to nearby police units with the location and other details, including the callers' real-time observation and any history of prior incidents. In addition to improving safety and reducing response times, the solution has improved efficiency for dispatchers and other staff, who can see current information from EMS, fire and police on a single screen. Up-to-date information refreshes constantly across multiple systems, and all responders have the same view of the information at all times. The ability to share data among disparate systems offers even more lifesaving capabilities. OPCD is currently working with Motorola Solutions to integrate capabilities for texting to 911 within the new system and is exploring options for working with video feeds as well as the statewide radio system. Especially the flexibility of the system plays a huge role in serving the city of New Orleans for year to come. It is a future ready solution for many reasons. Based on a Microsoft data warehouse, the back end is so extensible that new technology and data types such as text messages can be integrated without having to implement a brand new system or upgrade the current system. It can in time to come integrate more and more devices and things, as future technology becomes available.

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<sup>9</sup> <http://www.netmf.com/>



**Figure 4.1: OPCD IoT business model**

Figure 4.1 and table 4.1 shows how these new actions as well as future actions can be displayed in the IoT business model, to give a quick overview over how the system for OPCL looks today, and they can illustrate such a model every time new actions are integrated to get a picture of how their systems develop over time.

**Table 4.1: OPCD IoT business model review**

<b>Questions:</b>	<b>Organization</b>	<b>Industry</b>	<b>Ecosystem</b>
<b>Who?</b>	<ul style="list-style-type: none"> <li>- Callers/citizens</li> <li>- Dispatchers</li> <li>- First responders</li> <li>- Officers</li> <li>- Fire and emergency medical service personnel</li> </ul>	<ul style="list-style-type: none"> <li>- Citizens</li> <li>- Police</li> <li>- Fire departments</li> <li>- Medics /hospitals</li> </ul>	<ul style="list-style-type: none"> <li>- Public safety community</li> <li>- New Orleans</li> <li>- Ecosystem leaders: Microsoft and Motorola Solutions</li> <li>- Potential new partners: insurance companies, healthcare (in a broader sense), other states, product and service providers</li> </ul>
<b>What?</b>	<ul style="list-style-type: none"> <li>- Call incoming channels (Call systems, Mobile terminals)</li> <li>- Devices</li> <li>- Data and insights</li> <li>- Value driver: avert disasters and save lives</li> <li>- Risk: system breach, malicious attacks, spyware</li> </ul>	<ul style="list-style-type: none"> <li>- Call incoming channels (Call systems, Mobile terminals)</li> <li>- Devices</li> <li>- Data and insights</li> <li>- Value drivers: build better information flows between departments (police, fire, hospitals)</li> </ul>	<ul style="list-style-type: none"> <li>- Call incoming channels (Call systems, Mobile terminals)</li> <li>- Devices</li> <li>- Data and insights</li> <li>- Information exchange and extract for future use in the ecosystem</li> </ul>
<b>When?</b>	<ul style="list-style-type: none"> <li>- Planning on integrating capabilities for texting to 911</li> <li>- Exploring options for video feeds and statewide radio systems</li> <li>- Moving even more towards IoT when capabilities and developments allow it</li> </ul>	<ul style="list-style-type: none"> <li>- Future integration between more departments</li> <li>- Ability to create applications within industry</li> </ul>	<ul style="list-style-type: none"> <li>- Future integration between more departments and states</li> <li>- Ability to create applications between borders and cross-industrial</li> </ul>
<b>Where?</b>	<ul style="list-style-type: none"> <li>- Engager – utilize the technology and services offered by enabler (Microsoft and Motorola)</li> <li>- Enhancer – providing enhance services for the citizens</li> <li>- Reframe old processes to be more optimized</li> <li>- Across social media, data warehouse, devices</li> <li>- Server and database technology</li> <li>- Multiple systems</li> </ul>	<ul style="list-style-type: none"> <li>- Engager – utilize the technology and services offered by enabler (Microsoft and Motorola) to</li> <li>- Enhancer – providing enhance services for the citizens</li> <li>- Reframe old processes to be more optimized</li> <li>- Across social media, data warehouse, devices</li> <li>- Server and database technology</li> <li>- Multiple systems</li> </ul>	<ul style="list-style-type: none"> <li>- Engager – utilize the technology and services offered by enabler (Microsoft and Motorola)</li> <li>- Enhancer – providing enhance services for the citizens</li> <li>- Reframe old processes to be more optimized</li> <li>- Across social media, data warehouse, devices</li> <li>- Server and database technology</li> <li>- Multiple systems</li> </ul>
<b>Why?</b>	<ul style="list-style-type: none"> <li>- To transform and optimize emergency calls</li> <li>- Shorten response time</li> <li>- Improve safety</li> <li>- Eliminate error-prone manual processes</li> <li>- Lifesaving capabilities</li> </ul>	<ul style="list-style-type: none"> <li>- To transform and optimize emergency calls across sectors</li> <li>- Shorten response time</li> <li>- Improve safety</li> <li>- Eliminate error-prone manual processes</li> <li>- Lifesaving capabilities</li> </ul>	<ul style="list-style-type: none"> <li>- To transform and optimize emergency calls throughout the ecosystem</li> <li>- Shorten response time</li> <li>- Improve safety</li> <li>- Eliminate error-prone manual processes</li> <li>- Lifesaving capabilities</li> </ul>
<b>How?</b>	<ul style="list-style-type: none"> <li>- Up-to-date and real-time information</li> <li>- Streamlined interfaces</li> <li>- Server and database technology</li> <li>- Data warehouse</li> </ul>	<ul style="list-style-type: none"> <li>- Up-to-date and real-time information throughout the sector</li> <li>- Streamlined interfaces throughout the sector</li> <li>- Server and database technology data reports</li> <li>- Data warehouse reports which can benefit the sector and provide better insights</li> </ul>	<ul style="list-style-type: none"> <li>- Up-to-date and real-time information throughout the ecosystem</li> <li>- Streamlined interfaces throughout the ecosystem</li> <li>- Server and database technology knowledge and information</li> <li>- Data warehouse reports which can benefit the ecosystem and provide better insights</li> </ul>

In these sections I will explore what the new system means for OPCD in means of the organization, industry or sector and ecosystem level. In these sections assumptions are also made, according to information from the case.

#### **4.1.1 Organizational Level**

The birth of the IoT technology have provided new ways for OPCD to optimize their processes, and in turn save lives. By streamlining the interface, so all responders can see up-to-date information, accidents and attacks can be prevented. The new system provides great value to the citizens in New Orleans, it furthermore provides officers, firefighters and emergency personnel with all the information they need to save lives. It is important that the dispatchers and other relevant personnel knows how to utilize the functions in the new system, to get most value out of it for all involved parties. The system can collect and store data across devices and data types, with in turn provides real-time information.

OPCD can both be categorized as an Engager and Enhancer. They use the technology provided by Microsoft and Motorola, who in this case is the ecosystem leaders, to not only provide better services and optimized processes for the citizens, but also provide information they can utilize across the sector to transform and optimize emergency calls. The system shortens response time and improve safety by eliminating error-prone manual processes, and thus lifesaving capabilities. The system offers flexibility for future integrations and system needs when the capabilities, resources and innovation allows it. The solution offers mostly non-monetary benefits, but in can be assumed that it also includes monetary benefits, as the system offers optimized ways to use and plan OPCD's resources and personnel.

#### **4.1.2 Industry Level**

On the industry level the whole police, fire and emergency medical sector (EMS) have a better streamlined process and communication tool, which collects and stores data a cross a large platform, made up by technology, devices and other services, connecting better information flows between departments. All this data can be used to develop reports on the sector, and provide important insights and valuable information that in turn can better the process even more, saving lives.

#### **4.1.3 Ecosystem Level**

To review new ways of creating value flows and activities OPCD should understand the possibilities within their ecosystem of Microsoft and Motorola partners and collaborators. There may be endless possibilities to create new valuable relationships across sectors and industries. This may be in form of creating a collaboration with a smaller developer company to develop applications or products the citizens can use to increase safety. It may be a app the citizens can download to their smartphone, where they simply need to press a button if they fell threatened or observe others in trouble, which instantly notifies the OPCD with the persons' whereabouts. Other applications to e.g. instantly notify the citizens on possible dangers in a specific

area, or by natural concurrencies can also be developed using other ecosystem participants, which in turn can save lives. The opportunities are endless, with the right understanding of the flows in the ecosystem.

## 4.2 Other Insights

The illustration is based on a case which, normally does not use the business model concept to analyze their value creation and capture processes. But the case is chosen to illustrate the importance of all participants' part in the ecosystem, and the need for them to understand how they contribute to the overall IoT ecosystem. This is due to the fact that organizations like OPCD can gain important insights into even more possibilities for them in relation to IoT, while also contributing to important insights for other IoT ecosystem participants. They can create partnerships with sectors and businesses they never imagined working with in the past, and contribute to even more value for the customers, or in this case the citizens of New Orleans. It is even possible to imagine that the technology of IoT in the future can be used to prevent natural catastrophes having such deadly results as hurricane Katrina had. The possibilities are endless with the IoT phenomenon, and the more knowledge the ecosystem participants have, the more insights they can gain. However, if an organization does not possess the right capabilities, skills and understanding to use the system and tools optimally, they may risk causing an expensive negative affect for the stakeholders, who in turn will not gain value from such a strategy move. They furthermore expose the organization to many risk and vulnerabilities, when connecting all their systems and processes, and must also keep these possible issues in mind.

The model therefore offers a way, for not just businesses, but for all sectors to gain great insight into their overall role after integrating IoT technology or services into their processes. The model also provides a way for organizations not yet in the IoT ecosystem to prepare and plan for the whole organization, as well as other important actors for the move towards IoT. The model furthermore provides the flexibility for an organization to only review the areas important to them, as well as form it after their needs. This way the IoT business model framework can in broad terms be defined as an IoT review system, incorporating all organizations, individuals and sectors ability to play an important role in the IoT ecosystem.

## Chapter 5 - Discussion

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In this chapter I will discuss why it is relevant to research the concept of IoT business models from an IoT business perspective, rather than based on traditional business model theory. I will furthermore discuss the validity of the IoT business model framework in terms of its integration (logical coherence), relative explanatory power and relevance (Hedman & Kallin, 2003)

The lack of research on IoT from a business and ecosystem perspective have caused some gaps and shortcomings in the concept of IoT business models. The research surrounding this mostly uses traditional business model theory to analyze or form an IoT business model framework. These theories fail to incorporate the complexity of the synergies and dynamics of an IoT ecosystem, which a business becomes part of when moving towards an IoT business strategy. For a business to evolve with technology innovation the business model must first be renewed and transformed. It is no longer sufficient to perceive business models from a single firm point of view when IoT is introduced into the environment. Businesses are becoming parts of complex business ecosystems in today's networked world.

### 5.1 IoT Business Model Integration

The concept of IoT is the merging of the physical world with the digital world, and within this concept there are therefore central factors that must be understood and managed in order for IoT investments to generate profit. In certain instances, IoT technology are simply embedded, such as RFID, sensors and other hardware or software, which collect and exchange data, but not used by the business, which affects the business model on the resource level. Even though the technology collects and exchange data between other devices, the company's employees, or ecosystem participants need to understand how to utilize this data, before they generate value and become an essential part of the IoT ecosystem. The understanding of ones' employees' capabilities and skills, in connection with other participants in the ecosystems capabilities and skills, will provide necessary insights into the quality of synergies and dynamics in the ecosystem. Many businesses today are part of the IoT ecosystem without knowing it or understanding the concept, which in turn makes the business vulnerable to attacks. Examples of this is through HVAC systems which can be connected to the Internet, and if the Internet connection does not have firewalls, or network layers installed between other points of the business' system, like a retailers POS, it makes it an easy target for hackers, like with the Target case. Even if the IoT concept is to some degree used by the business, it may not be used effectively, or even if used effectively it may affect other activities negatively. If the business does manage to improve profit by utilizing IoT technology, the business might not create competitive advantages, as competitors could imitate, or be a step ahead due to the constant evolving and dynamics of IoT. Connecting IoT technology contributes to a potential major resource for the company, but for the company to fully exploit the many opportunities this resource brings the company needs the right capabilities and skills. Embedding and integrating the IoT technologies or utilizing the information gathered by these requires extensive knowledge and understanding

of the possible risk associated, as the only way a company can do this is by becoming part of the digitalized and networked IoT ecosystem, which is still in a maturing state when it comes to the technology, regulations and standardizations. Deep insights and frameworks surrounding IT security is essential for even the least technological collaborators in the ecosystem. It is therefore important to understand how to measure the security of different aspects of the system. Even though IoT is predicted to disrupt almost every industry it is far from optimal for some businesses to get an early start in the IoT ecosystem without extensive planning. This can result in a negative affect on the business' relationship to their customers, if their customers or other stakeholders for example lack adoption skills or have trust issues towards the concept, as IoT have already brought with it many tells of attacks and vulnerability. Customers may even perceive the quality of the IoT products or services as negative, as improvements in one activity may affect another negatively. The promised improvements many researchers and practitioners promote may not result in improved profits if managers and users are not able to materialize on changes made. It is important that the company possess the right knowledge, and have clear aspirations and furthermore that the timing is right, for the company to collect the incentives promoted in the many possibilities of IoT, before a business should join the ecosystem.

Though the concept of IoT is on every IT business mind and becoming a strong part of future strategy planning, the concept and technology behind it is far from mature. The IoT business model proposed in the thesis takes all these aspects into consideration, and if used optimally, it can support any business becoming a part of the IoT ecosystem by providing the necessary insights into ensuring the business is ready for such a move. What may be even more important is the use of the model to ensure that the IoT ecosystem is ready for the business. A business model for the IoT ecosystem must therefore provide more extensive insights than traditional business model thinking does, which will be discussed next.

## 5.2 The Thesis IoT Business Model Framework in Comparison

The three IoT business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014) incorporate in one way or another traditional business model thinking. Sun et al. especially base their DNA business model on business model and business model innovation theories, which in turn causes great lack in the framework, as discussed in section 3.2.1 – 3.2.1.1. Of the three frameworks Sun et al.'s is the least extensive, and focuses mostly on traditional business model thinking, and therefore fails to incorporate the ecosystem the business becomes part of when moving towards an IoT strategy, but merely focuses on the industry. Though Turber et al. succeeded in incorporating the complex ecosystem perspective into their framework, the artifact fails short of providing an extensive view over all value creation and capture processes, as well as the challenges and barriers connected to these. Some might question the need to incorporate the challenges and barriers, as they do not illustrate value flows and activities, but they do however, illustrate what prevents some flows and activities, which are expected to provide value. These insights are just as important for companies wanting to succeed in the IoT ecosystem. It is therefore essential for companies wanting to integrate IoT technology or utilize the data extracted by such technologies to

provide valuable new products and services for their stakeholders and customers to analyze the IoT ecosystem more extensively than what traditional business model frameworks provide insights into.

Westerlund et al.'s framework provided more of a reference framework, rather than a business model concept for the IoT. This framework contributed to highly essential insights into the value creation and capture processes between actors in the ecosystem, as well as the interaction between technologies, flows and activities. The framework furthermore highlighted potential issues and barriers in the IoT ecosystem, such as diversity of objects, immaturity of innovation, and unstructured ecosystems. Much of my IoT business model framework have been built around these insights. However, Westerlund et al.'s framework fails to provide an extensive overview over these flows, activities and issues throughout the IoT value chain, but offers a framework to support future research in this area.

By incorporating all the essential insights from the research surrounding IoT from a business and ecosystem perspective, as well as including the many critical insights from analyzing the three IoT business model frameworks I was able to form an extensive IoT business model framework, which incorporates all these value creation and capture flows and activities, as well as include the possible challenges and barriers associated with these, which can be utilized throughout the IoT value chain. This was possible due to the fact that I built the business model framework up around the IoT concept, rather than trying to fit the IoT concept into the traditional business model concept.

### 5.3 Relevance

Researchers and practitioners have predicted that the affect of IoT on businesses will be as disruptive as the Internet itself, so it is not hard to realize the impact IoT will have on the business model concept. The gap in research surrounding IoT business models creates another potential problem for many traditional businesses, as they lack the capabilities and competencies to create an extensive IoT business model plan. With the maturing of the concept of IoT there have been extensive research surrounding the IoT technologies, however, it is just as important if not more to research the business aspects, as many businesses will not take part in the development and utilization of the IoT products and devices, but merely use the data collected by these. These companies therefore need to understand what part they can play in the ecosystem, and how to plan accordingly, so they do not become obsolete like many companies did when the Internet became mainstream.

A very important aspect of the proposed business model is the flexibility and inclusion of the IoT concept from an organizational, industrial and ecosystem perspective. The model includes both traditional business model theory components, business ecosystem components and IoT components, and can be used to create an extensive plan or overview over where the company's IoT strategy is heading. The strength of the model is furthermore the inclusion of the challenges and barriers which are associated with many of the IoT activities and flows. There is a strong need to look at the regulation and standardization surrounding the IoT

technologies and services, as this creates a great barrier for many companies who cannot risk possible attacks or vulnerabilities connected to these.

The concept of IoT have a long way to go yet, and includes an array of challenges for not only companies, but also governments and institutions and even for innovation itself. The research field associated to IoT ranges therefore from every possible aspect, from the network side, to the regulations, standardizations and educational aspects and even IT security, the list goes on. As the concept of IoT is still in a maturing stage, associated to the endless possibilities only limited by ones' imagination, as well as the high number of challenges, issues and barriers, it is important to keep all these aspects in mind, so one is not blinded by the perception of infinite success with IoT technologies, as this is far from the case. There are obvious limitations with the proposed model, being based on theory and illustrations. The lack of empirical data associated with the overall model can provide some issues with the verification of this. The model can however form basis for future research, associated with a strong empirical focus to test the model. The model seeks to incorporate all types of IoT actors, from business strategies such as the identified Enabler, Engager and Enhancer, but also outside of these strategies, such as learning institutes and governmental initiatives, who all play an important role in promoting the IoT concept.

## Chapter 6 - Conclusion

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The concept of IoT can play many roles for different businesses and individuals, and it far from has just one role when incorporated into ones' life or business. The thesis focus lies within IoT from a business and ecosystem perspective, to support the construct of a business model framework for the IoT. IoT have great potential to innovate and improve businesses, but there are still many challenges and barriers, which can have a negative affect on the business. A deeper understanding of all these essential insights is therefore critical for anyone wanting to take part of the IoT concept. The thesis therefore had two main aims, firstly to clarify which aspects are most essential when researching the concept of IoT from a business and ecosystem perspective, and secondly to develop an IoT business model framework which incorporates these essential aspects, which in turn can support a company to understand, analyze, communicate, and manage strategic-orientated choices within the IoT ecosystem.

In the initial stage of the thesis I claimed that the three IoT business model frameworks by Sun et al. (2012), Turber et al. (2014) and Westerlund et al. (2014) failed to incorporate much of the complexity associated with an IoT ecosystem, and furthermore simplify this complexity, without giving a superficial view on the concept of IoT for businesses. To support my claim, I performed an extensive research on IoT from a business and ecosystem perspective, and through this research I was able to identify critical components, which were essential to incorporate into a possible IoT business model framework, so as to give a company a holistic and realistic overview over a potential IoT strategy and ecosystem. In chapter 2 I identified the significance of viewing an IoT business model throughout the IoT value chain; the organization, industry and ecosystem, to identify the *who, what, when, where, why* and *how*, throughout the IoT value chain. For a business to truly understand the many opportunities as well as challenges and barriers associated with the IoT concept, the company must first understand what role their business strategy can play in an overall IoT ecosystem. For this I identified three main strategies associated with the IoT ecosystem, namely the Enabler, which develops and implement the underlying technology. The Engager, which designs, creates, integrates and delivers IoT services to customers, thereby becoming the direct link between IoT and the market. And lastly the Enhancer, which device their own value-added services, on top of the services provided by Engagers, which are unique to IoT, thereby finding new ways to engage with customers or other stakeholders. The three identified business strategies all contribute to, and create and capture value throughout the IoT value chain.

The extensive research furthermore provided the knowledge necessary to form a framework tool to help analyze the three IoT business model frameworks, which was based on the above mentioned findings, and provided an extensive overview over the individual frameworks focus and aim. The tool was furthermore used to identify other important insights, like similarities and differences between the three frameworks. By reviewing the individual frameworks using the review tool, which is illustrated in figure 2.3 in chapter 2, I was able to create a complete view over the gaps and shortcomings in the frameworks, but at the same time

also use it to identify important insights gained from the frameworks, which was discussed in the previous chapter. The results from the analysis and review of the three frameworks provided an overview over what the IoT business model framework should be able to focus on, to create an understandable and extensive approach for a business either already a part of an IoT ecosystem, or seeking to become part of one. The framework offers a broad spectrum of insights, which the company can review as needed, thereby also offering flexibility to incorporate the different stages of the ecosystem, as well as adoption to innovation, but also review the state of an IoT ecosystem. By forming an IoT business model, which incorporates the whole IoT value chain, as well as helps identify the who, what, when, where, why and how, the framework contributes to an in-depth and flexible approach for creating business value by supporting a business to understand, analyze, communicate, and manage strategic-orientated choices.

The model provides an extensive overview over the IoT value chain. On the organizational level, which represent the micro level, the company must seek to understand the resources and capabilities available. It should also understand its role in the IoT ecosystem, depending on what IoT strategy they belong to; Enabler, Engager or Enhancer. A company's competitive advantage relies on creating more value than its competitors, this however requires innovation, and therefore the value creation of the individual companies depends on its ability to innovate. For some companies it will contribute to innovative success when applying IoT technology into their products and services, while for others it will create a negative affect, like in the case of Target. Most importantly for traditional companies who are not born in the digital environment is understanding the risk associated with moving to the IoT ecosystem to early or too late. In the industry or sector level the IoT brings new collaborations, which surpasses those from traditional businesses. It is therefore essential for companies to understand their sector and industry level, and which players are already or planning to move towards the IoT ecosystem. In some cases, a first-mover role will have a negative affect in the business industry. The pace of innovation has never moved faster than today, and what seems to first be ready in five years, can quickly become mature within a year. Companies and industries can no longer plan for five years ahead and think that the dynamic environment will look the same as what they thought it would five years ago. Innovation gives birth to innovation and this trend is quickly spreading. Companies born in the cloud have the benefit of agility and flexibility, and soon whole industries will become part of this trend. Lastly the company must understand the overall ecosystem they are part of. They must know who the ecosystem leader(s) are, and which goals and motivations there are in the ecosystem. The overall ecosystem state can either contribute to success or failure for individual companies, who chose the wrong IoT ecosystem. All these insights can be identified when utilizing the proposed IoT business model to get a deeper understanding of ones' business in the IoT ecosystem. The IoT business model therefore provides an extensive approach to identifying, first and foremost the roles of the business strategy, Enabler, Engager and Enhancer. Next it helps identify the who, what, when, where, why and how, throughout the IoT value chain, and provides the knowledge necessary to understand, analyze, communicate, and manage strategic-orientated choices surrounding the IoT concept, and throughout the ecosystem.

## Chapter 7 – Reflection

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When I started my thesis I had a clear idea that I wanted to research IoT from a business model perspective, as much of the earlier research I had done throughout my Masters study at CBS about the subject of IoT showed a clear research gap in this area. I have read through endless amounts of articles, papers, blogs and more about the subject, and though some touch the subject that IoT will disrupt and innovate traditional business models, few have researched this area in depth. The method I originally wanted to utilize throughout the thesis was a system dynamic simulation approach.<sup>10</sup> I wanted to use this method to model, simulate and verify my IoT business model framework based on the preliminary research of Westerlund et al.'s (2014) proposed *value design* tool. For this I was intending to research the relationships of Enabler, Engager and Enhancer according to the value design tool, exploring both the external and internal environment; what pushes the innovation in the ecosystem, the barriers, cooptation and more. All these components were to play a role in the system dynamics equation, which was to illustrate the relationship and synergies between the different components. However, due to issues with finding theory to back the foundation and relationship of the equation I deemed it necessary to take a different strategic approach to the thesis' model. I was aware of the risk associated with such a complex approach to a still novel research topic, but felt it was a very interesting research approach. Furthermore, researching the subject with the system dynamics approach in mind from the start gave me a clear advantage, as I constantly had the dynamic relationship and synergies in mind between the different components I identified throughout the research process. This provided an understanding on how the different components affected the overall IoT ecosystem. For example, challenges and barriers when entering the IoT ecosystem will never rise exponentially, as these components will sooner or later force organizations to think innovatively to solve these issues, pushing the ecosystems health upward as it opens up for more competition when an organizations survival instinct is activated. The insights I gained by taking such a complex approach have furthermore helped identify additional gaps and shortcomings in the IoT research from a business perspective.

When I concluded that this research approach and equation would be too difficult to prove I decided on a theoretical approach instead. In this time period I had researched the subject extensively and found numerous gaps and limitations in the theoretical research surrounding IoT business models. My research aim has throughout the process been focused on the concept of IoT business models. From here I performed a more extensive literature search surrounding IoT business models, and for this I established some criteria's which were clarified in chapter 2. Taking a more theoretical approach I was also aware of the consequences hereof and feared the outcome in it self would be limited, due to the limited research surrounding the IoT business model. However, this also pointed to a clear research need, and by taking a different approach to the concept than the previous frameworks on the subject I was able to identify further needs and important components,

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<sup>10</sup> See Appendix C (the SD section have not been corrected since deciding to not include it in the thesis)

which none of the other frameworks take into consideration. Throughout the process of researching this framework I also developed another IoT business model, which can be seen in Appendix E. The model took a 3-dimensional take on the business model, still incorporating the who, what, when, where, why and how. However, this model was deemed to complex, taking into consideration that I wanted to uncomplicated the complex concept of the IoT phenomenon.

Not all might agree with me on my findings and the importance hereof, but I will argue that not one person who understands and is familiar with the concept of Internet of Things will agree that it is not an important subject to research from a business model perspective. As IoT in time will disrupts almost all, if not all sectors, industries and the way people live their life, it will certainly disrupt the concept of traditional business model thinking, as the traditional concept does not incorporate the complexity of the digital environment from an ecosystem perspective. From a practical viewpoint it is not hard to see the issues traditional businesses struggle with as the IoT phenomenon gains traction in the years to come. Huge IT corporations like Microsoft leave smaller companies not willing to move towards cloud technology behind, and leave these to fight for their survival. If IT companies have a hard time surviving in this environment it is only a matter of time before this trend hits traditional non-digital companies.

The whole learning process have been a huge privilege in itself, though it has been filled with insecurity and doubt. It has given me a new found respect for researchers who does this for a living. The knowledge gained throughout the process have been enormous, and though I doubt I will ever feel that the thesis is complete, I am overall very satisfied with the outcome, as I believe the model can contribute to a higher understanding on the opportunities and challenges, which follows the IoT concept. The model also offers some important questions all companies should be able to answer before moving towards the IoT ecosystem. There is no doubt that including empirical data to the thesis would help validate the model, however, all data and information about IoT can be found on the internet, and it is close to impossible to find relevant datasets on the subject, due to its novelty.

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List of Appendices

Appendix A: IoT literature overview used to produce the literature matrix

Author(s) / Research organization	Type (e.g. article, research rapport, empirical paper ect.)	Focus area/question, purpose and base:	Answers:	Important outcome
CERP-IoT, 2011, 2013, 2014, 2015	Industry rapport	Every aspect of IoT, to address the large potential for IoT-based capabilities in Europe and to coordinate the convergence of ongoing activities	Industry questions related to IoT. The layers of technology, market deployment, innovation, industry aspects of IoT, standardization and barriers - Customers: who are the core customers, where are they? Have they changed? - Markets: have the markets changed? Should the company change market position? - Channel: what's right channel to offer products/services? - Infrastructure: who are the key partners/ key activities/ key resources?	The five W's and how? Opportunities within IoT, challenges, research needs, barriers, technological perspective, stakeholders, synergies = who? What? When? Where? Why? And how?
Sun et al., 2012	Theoretical research article	<b>Purpose:</b> Operable business model based on DNA model from the perspective of designing a business model in the IoT. <b>View:</b> IoT as a three layered environment; sensing, <b>Based on:</b> Holistic approach, Uses business model and business model innovation theory.	- Customers: who are the core customers, where are they? Have they changed? - Markets: have the markets changed? Should the company change market position? - Channel: what's right channel to offer products/services? - Infrastructure: who are the key partners/ key activities/ key resources?	DNA business model; Design, Needs and Aspirations  = How? What? And Why? And Who? From a industry perspective
Turber et al., 2014	Empirical research	<b>Purpose:</b> Building an IoT business model framework <b>Based on (theoretical):</b> Design science research approach using Information systems, Service-dominant	Addresses the need for a business model framework in IoT-driven market environments, which recognizes the specific impact of digitization	Framework design for a business model framework in the IoT context, which incorporates a network-centric view, the different layers of digitalized products and IoT ecosystem participants of the external environment

		<p>logic and business model research</p> <p><b>Based on (empirical):</b>          Prototyping, cross-industry BM workshops, review with experts from research and practice, semi-structured interviews with BM workshop participants after cross-industry workshops</p>		<p>= Who? Where? Why?</p>
<p>Westerlund et al., 2014</p>	<p>Theoretical research paper</p>	<p>Investigates challenges pertaining to business model design in the emerging context of the IoT</p> <p><b>View:</b>          IoT as a business ecosystem rather than just a technology platform. Designing ecosystem business models instead of firm centric BM.</p> <p><b>Based on:</b>          Ecosystem business models, adoption to innovation, unstructured ecosystems</p>	<p>How to move to a ecosystem business model to incorporate the complexity of IoT and the concepts of object diversity and innovation adoption</p>	<p>Value design tool; value drivers, value nodes, value exchanges, value extract</p> <p>= Who? What? Where? Why? How? And to some degree When?</p>
<p>Mazhelis et al., 2012</p>	<p>Theoretical research paper – literature survey</p>	<p>Defining the IoT ecosystem using business ecosystem theory</p> <p><b>Based on:</b>          Natural life ecosystem, business ecosystem</p>	<p>Defining an IoT ecosystem from a technological and business perspective, defining roles in the IoT ecosystem</p>	<p>IoT ecosystem from a technological and business perspective using business ecosystem theory</p> <p>= Where? What? Who?</p>

Burkitt, 2014	Article on strategy-business.com	A strategist guide to the IoT	The evolution and opportunities in IoT, technology, services, products, IoT business strategies,	Enablers, engagers, enhancers, opportunities, challenges, defining roles, a practical take on IoT, capabilities,  = What? Where? Who? Why? (When?)
Patel & Veira, 2014	Article, interview of Joep van Beurden on mckinsey.com (CEO of semiconductor company CSR)	Industry perspective on IoT		Industry view on IoT
Bauer et al, 2014	Article on mckinsey.com	The opportunities in IoT on the semiconductor industry	Semiconductors, supplier attention, technological advances, increasing demand, emerging standards	supplier attention, technological advances, increasing demand, emerging standards
Walker, 2014	Article on ComputerWeekly.com	Legal considerations of IoT	Cyber security, language and culture, Data protection, regulation and standards, advantages of IoT	Challenges and barriers of IoT, what to keep in mind
Turber & Smiela, 2014	Research paper (research in progress)	Business model type for the IoT	Digitized objects, business archetypal, Service-dominant logic, previous business model approaches	Digitized objects, business archetypal, Service-dominant logic, previous business model approaches
SAP, 2014	Industry rapport	Reviewing how IoT is redefining enterprise IT	The vision and reality of IoT, and how to thrive in a connected world	Future aspects and implications of IoT
Höller et al., 2014	Book	High-level analysis of Machine-2-Machine (M2M) and IoT		Technological and market insights

Microsoft, 2015	Industry rapport	Ten reasons your business needs a strategy to capitalize on the Internet of Things today	Steps to becoming a truly digital business	Industry insights
Hui, 2014	HBS Press articles	How IoT changes traditional business models	Value creation and capture from a IoT mindset	Traditional product mindset vs. IoT mindset, value creation and capture in IoT compared to traditional business models
La Marca, 2015	Industry article	Hype surrounding the IoT and wearables based on Gartner's hype cycle		Predictions surrounding the IoT hype
Oriwoh et al, 2013	Conceptual paper	Producing guidelines for deployment approaches for IoT by researching the things in IoT	Different concerns related to IoT	Challenges and barriers involved in the IoT concept

## **Appendix B: Business models and Business model innovation**

### ***The concept of Business Models***

The first systematic and comparative account of growth and change in the modern industrial corporation was presented in Alfreds Chandler's seminal *Strategy and Structure (1962)* (Chesbrough & Rosenbloom, 2002:530). Chandler showed how challenges of diversity implicit in a strategy of growth called for imaginative responses in the administration of an enterprise. Ansoff (1965) built upon the ideas of Chandler (1962) and applied them to emerging concepts of corporate strategy, where strategy came to be seen as a conscious plan to align the firm with opportunities and threats posed by its environment (Chesbrough & Rosenbloom, 2002:530). Business strategy differentiates from corporate strategy in the way that business strategy defines product and market choices made by a division or product line management in a diversified company, while a corporate strategy is a superset of business strategy. A company will only have one corporate strategy, but may incorporate into its concept of itself several business strategies (Chesbrough & Rosenbloom, 2002:530, 531). Therefore, a firm's current businesses influence its choice of likely future businesses as well. A firm's technological position can help a business enter nearby business areas, as experience in 'related' technologies reduces the cost of entering into adjacent areas (ibid.). Much of the technological management literature suggest that firms have great difficulty managing innovation that fall outside of their previous experience, where they can not apply their earlier beliefs and practices. The root of the difficulty can not be agreed upon by authors; whether it lies in the characteristics of the technology itself, the management processes employed to manage it, or the means used to access the surrounding resources. However, if firms invest in integrative capabilities, they may indeed develop the ability to manage new technological opportunities effectively (Chesbrough & Rosenbloom, 2002:531, 532). Chesbrough and Rosenbloom's (2002) research contributes to the concept of business model as a construct that can inform these earlier perspectives, providing a coherent framework that takes technological characteristics and potentials as inputs, and converts them through customers and markets into economic outputs (ibid.) They thus define the business model as a focusing device that mediates between technology development and economic value creation (ibid.:532). Firms failing to act effectively in the face of technological change can be understood as the difficulty these firms have in observing and then executing new business models, when technological change requires it. Chesbrough and Rosenbloom (2002:532) therefore argue "*that firms need to understand the cognitive role of the business model, in order to commercialize technology in ways that will allow firms to capture value from their technology investments, when opportunities presented by its technologies do not fit well with the firm's current business model*" (ibid.). The recent focus on researching the business model concept is believed to have been driven by the advent of the Internet (Zott & Amitt, 2010:5). It is therefore not surprising that Chesbrough and Rosenbloom (2002) argue that business models mediates between technology development and economic value. This definition is however limited when seeking to research the IoT ecosystem as technology is no longer a tangible object, but something that merges the physical and digital world.

In the literature of business models there is a lack of consent on a common definition, as researcher frequently adopt idiosyncratic definitions used to fit their studies, which does not conciliate with each other. This have resulted in a high accumulation of definitions (Zott et al., 2010). The of concept business models is particularly popular among e-businesses and within e-business research. But the empirical use of the concept has been criticized for being fuzzy, superficial and without theoretical grounds (Hedman & Kalling, 2003:49). However, the term business models have received increased attention the last 15-20 years due to the Internet (Zott et al., 2011). Mutaz and Avison (2010) argues that the business models are fundamental to any organization, as it provides powerful ways to understand, analyze, communicate, and manage strategic-oriented choices among business and technology stakeholders. It is important that organizations have a clear concept and understanding of their business model, as they cannot afford ‘fuzzy thinking’ about this concept (ibid). As mentioned there is a lack on a common definition and there are therefore numerous definitions of business models. The table below shows a few examples of the variation of business model definitions provided by the research of Zott, Amit and Massa (2011) and Mataz and Avison (2010) which have been modified for the relevance of the thesis.

**Table 4.1: Selected Business Model Definitions (modified from Zott et al. 2011:6; Mataz & Avison, 2010)**

<b>Authors, Year</b>	<b>Definition of Business Models</b>	<b>Thematic indicators</b>
Timmers, 1998	<i>“an architecture of the product, service and information flows, including a description of the various business actors and their roles; a description of the potential benefits for the various business actors; a description of the sources of revenues”</i> (p. 2).	<ul style="list-style-type: none"> <li>• Architecture</li> <li>• Value proposition</li> <li>• Business actors and roles</li> <li>• Revenue sources</li> </ul>
Amit & Zott, 2001; Zott & Amit, 2010	<i>“The content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities”</i> (2001:511). The authors further evolved this definition to conceptualize a firm’s business model, based on the fact that transactions connect activities, as <i>“a system of interdependent activities that transcends the focal firm and spans its boundaries”</i> (2010:216)	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Structure</li> <li>• Governance</li> </ul>
Chesbrough & Rosenbloom, 2002	<i>“the heuristic logic that connects technical potential with the realization of economic value”</i> (p. 529)	<ul style="list-style-type: none"> <li>• Coherent framework</li> <li>• Mediating construct</li> <li>• Technology</li> <li>• Economic value</li> </ul>
Magretta, 2002	<i>“stories that explain how enterprises work. A good business model answers Peter Drucker’s age old question: Who is the customer? And what does the</i>	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Customers</li> <li>• Revenue Source</li> </ul>

	<i>customer value? It also answers the fundamental question every manager must ask: How do we make money in this business? What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?"</i> (p. 4).	
Morris et al., 2005	<i>"concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets"</i> (p. 727). It consists of six fundamental components: Value proposition, customer, internal processes/competencies, external positioning, economic model, and personal/investor factors.	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Customer</li> <li>• Internal processes/competencies</li> <li>• External positioning</li> <li>• Economic model</li> <li>• Business actors</li> </ul>
Haaker et al., 2006	<i>"A blueprint collaborative effort of multiple companies to offer a joint proposition to their consumer"</i> (p. 646)	<ul style="list-style-type: none"> <li>• Blueprint</li> <li>• Network of firms</li> <li>• Customers</li> <li>• Value proposition</li> </ul>
Kallio et al., 2006	<i>"The means by which a firm is able to create value by coordinating the flow of information, goods and services among the various industry participants it comes in contact with including customers, partners within the value chain, competitors and the government."</i> (pp. 1-2)	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Information/goods/services</li> <li>• Industry participants: customers/partners/competitors/government</li> </ul>
Rajala & Westerlund, 2007	<i>"The ways of creating value for customers and the way in which a business turns market opportunities into profit through sets of actors, activities, and collaborations"</i> (p. 118)	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Set of actors</li> <li>• Revenue</li> </ul>
Johnson, Christensen, & Kagermann, 2008	<i>"consist of four interlocking elements, that taken together, create and deliver value"</i> (p. 52). These are customer value proposition, profit formula, key resources, and key processes.	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Revenue source</li> <li>• Key resources</li> <li>• Key processes</li> </ul>
Teece, 2010	<i>"articulates the logic, the data and other evidence that supports a value proposition for the customer, and a viable structure of revenues and cost for the enterprise delivering that value"</i> (p. 179)	<ul style="list-style-type: none"> <li>• Value proposition</li> <li>• Customers</li> <li>• Revenue structure</li> <li>• Cost structure</li> </ul>

The business model definitions above show the variety in how the concept is defined and perceived, what they are outlined as, and what elements and components they are said to consist of. This wide variety and lack of a common definition has led researchers to attempt to categorize the different concepts further, which

business models attempt to clarify. Zott, Amit and Massa (2010) identify some different themes related to business model literature, such as (1) the business model is a new unit of analysis, (2) a holistic approach towards how firms do business, (3) organizational activities play an important role in business model conceptualization, and (4) that business models seek to explain both value creation and value capture. The latter being the primary focus in this research. Zott, Amit and Massa (2010) drew on literature which does not directly employ the term business model, such as the work on new organizational forms, ecosystems, activity systems, and value chains and value networks, to synthesize the main insights that they bring to bear on the study of business models (Zott et al., 2010:2). Zott, Amit and Massa (2011) divide business models in three different categories, where the categories either can be used individually or in relation to each other. The categories are (1) e-business archetypes, (2) business model as cost/revenue architecture, and (3) as an activity system, when related to strategy studies (ibid.). The most common definitions of business models go under the category of cost/revenue architecture, as they focus on creating and capturing value. Business models has especially been presented as a new unit of analysis, integrating various theoretical perspectives on value creation (Amit & Zott, 2001). The business model concept consists of six major functionalities (Chesbrough & Rosenbloom, 2002; Osterwalder et al., 2006), which are: value proposition, customer market segment, value chain, cost and profit structure, the strategic position of the firm in a value network, and the formulation of a competitive strategy. Beyond semantic issues concerns of business model research seem to be related to the challenges of innovation and implementation of new business model in practice. According to McNamara et al. (2011) competing companies need to “*know what kind of business model configurations are possible within an industry*” as well as know how and whether it is possible for firms to change between models. The concept of business model is therefore further addressed in the domains of innovation and technology management in the next section.

### ***Business model innovation***

A successful company should be able to embrace market challenges as opportunities, as innovation play a very important role in facing a market. Not only can innovation bring continuous change to successful companies, but it can also enable struggling companies to survive. Business model innovation is therefore becoming an important source for competitive advantage, as business models allow innovative companies to commercialize new ideas and technologies, and can be viewed as a source of innovation (Sun et al., 2012:3; Massa & Tucci, 2013:424). In a 2006 study by IBM Global Service Report it shows that the CEOs who had been interviewed considered business model innovation as the strongest drivers of business differentiation, value creation, and sustainable competitive advantage, while product and service innovations are less sustainable (Sun et al., 2012:3; IBM Global Service, 2006). Many companies like Dell, IBM, and Ikea have achieved great success in the last decade by creating new business models or renewing traditional business model. There has been much focus on business model innovations as being the best way to improve profit as well as avert competitive threats in the long run as business model innovators have a growth in operating margin that are more than five times those of product/service innovators (Sun et al., 2012:3). Literature on

technology management and entrepreneurship recognize that innovative technologies or ideas per se have no economic value. It is however through the design of appropriate business models that managers and entrepreneurs are able to unlock the yield from investments in R&D and connect it to a market (Massa & Tucci, 2013:424).

An example of business model innovation is Xerox that invented the first photocopy machine, however the technology was too expensive and could not be sold. Xerox's problem was solved by managers who invented a new business model to lease the machines instead. Here the business model is viewed as a manipulative device that mediates between technology and economic value creation (Chesbrough & Rosenbloom, 2002). Business models becomes a vehicle for innovation by allowing commercialization of novel technologies and ideas (Massa & Tucci, 2013:424). Business model innovation is especially valuable in time of instability, as it can provide a way for companies to break out of intense competition and help address disruption, like regulatory or technological shifts, which demand fundamental new competitive approaches (Lindgardt et al., 2009:1). Business models furthermore represent a new dimension of innovation itself, which stretch over the traditional modes of process, products, and organizational innovation. Companies can use business models to compete through, and a new dimension of innovation may be source of superior performance, in even mature industries (Massa & Tucci, 2013; Zott & Amit, 2007). Massa and Tucci (2013:424) propose the business model innovation may refer to “(1) *the design of novel BMs for newly formed organizations, or (2) the reconfiguration of existing BMs*”. They use the term *business model design (BMD)* for the first reference and *business model reconfiguration (BMR)* for the latter and argue that business model innovation is a subset of business model design and reconfiguration (ibid.). Björkdahl (2009) apply the notion of business models for studying technology diversification and cross fertilization efforts. When seeking to diversify their technological portfolios some companies introduce new technologies into existing products, exploiting the opportunities arising from such ‘*cross-fertilizing*’ technologies. Björkdahl explore the role of business model in value capturing from technology cross fertilization (Zott et al., 2010:18). Björkdahl (2009) argue that if the economic value potential of the new technology is to be captured when integrating new technologies into the technology base of a product, which will open up new subspaces in the existing technical performance and functionality space, new business models are required (Zott et al., 2010:19). Business models however not only entail consequences for technology innovation; they can also be shaped by them. In a case study by Calia, Guerrini, and Moura (2007) they present how technological innovation networks can provide resources necessary for business model reconfiguration. The result of the case study presents a technology company in the aluminum industry, finding that the impact of technology innovation, as a result of a collaborative effort in a network of technological partners, might not be limited to the new product's technological features, but can also result in changes in the company's operational and commercial activities, which ultimately correspond to a change of the business model (Zott et al., 2010:19).

With IoT disrupting nearly every industry in the near future there are many advantages for companies to develop business models which can withstand these disruptions and use this paradigm shift to their advantage. The right business model can enable companies to gain first-mover advantage during the further development of IoT, as well as speed up the pace of transformation or strategic realignment to meet the challenges of IoT. The right business model can also help seize the opportunities in the IoT ecosystem (Sun et al., 2012:3). Existing business model frameworks are sufficient, when it comes to examining the challenges faced by single existing organizations (Johnson et al., 2008) but less suited when it comes to analyzing the independent nature of the growth and success of companies that evolve in the same innovation “ecosystem” (Weiller & Neely, 2013).

### **Appendix C: System Dynamics**

System dynamics (SD) is a powerful methodology and computer simulation modeling technique, which is used to frame, understand and discuss complex issues and problems, and studying and managing complex feedback systems, such as those found in business and other social systems (Radzicki & Taylor, 2008; Hajiheydari & Zarei, 2013:159). The concept was originally developed in the 1950s to help corporate managers improve their understanding of industrial processes (Radzicki & Taylor, 2008). SD is an aspect of system theory, which is a method used to understand the dynamic behavior of complex systems. The methods basis is the recognition that the structure of any system (the many circular, interlocking, sometimes time-delayed relationships among its components) is often just as important when determining its behavior as the individual components themselves. This is important as in some cases the behavior of the whole cannot be explained in terms of the behavior of the parts (Wikipedia, 2015:4). In SD there are generally two basic approaches (Harris & William, 2005:3):

- 1) There are approaches that *map* the dynamic relationships, and thereafter use a variety of methods to understand the possible consequences of those relationships or develop theories about them. These are essentially very sophisticated forms of program logic or concept mapping. Examples of this form of SD include casual loop diagrams and system archetypes, which estimates behavior from structure without simulation. These take delay durations and polarity of feedback into account in some cases (ibid.).
- 2) Other approaches *simulate* the dynamic relationships in order to explore the consequences of different amounts of intervention, timing, delay, and feedback. Here the simulation is not intended to give you the ‘right’ answer, which is important to remember. But it does help deal with feedback and delay, which is an area most do not do well intuitively (ibid.).

The following steps are shared by both approaches (Harris & William, 2005:3):

- Identify the problem, puzzle, evaluation question, or issue.
- Develop a dynamic hypothesis explaining the cause of the problem.
- Build a model of the system at the root of the problem.

- Ensure the model reflects the behavior seen in the real world, or explore similar models that have already been tested.
- Play around with the model to see what insights it gives you about the issue
- Draw a conclusion from these insights (ibid.).

The SD diagrams elements are feedback, accumulation of flows into stocks and time delays (Wikipedia, 2015:4). The different components of the SD approach will be explored in the following sections.

### Casual loop diagrams

A causal loop diagram (CLD) aids in visualizing how different variables in a system are interrelated. When utilizing a SD methodology, a problem or system – in this case, an ecosystem – is first represented as a CLD. This is a simple map of a system with all its constituent components and their interactions. A CLD reveals the structure of a system, as it captures the interactions and consequently the feedback loops. This method makes it possible to ascertain a system's behavior over a certain time period, when the structure of the system is understood (Wikipedia, 2015:4).

The CLD consists of a set of nodes and edges, where the nodes represent the variables and edges are the links that represent a connection or relation between two variables (Wikipedia, 2014:1). If the relation between the variables is positive the two nodes will change in the same direction, where the two variables will either increase or decrease together. If the relation between the variables is negative the two nodes will change in opposite directions, i.e. if the node in which the link starts to increase, the other node will decrease and vice versa (ibid.). An important feature of CLDs is closed cycles in the diagram; a closed cycle is either defined as a reinforcing or as a balancing loop. In a reinforcing loop, the cycle in which the effect of a variation in any variable propagates through the loop and returns to the variable reinforces the initial deviation. Ergo, if after going around the loop, one ends up with the same result as the initial assumption there is speak of a reinforcing loop, where reinforcing loops have en even number of negative links, and are associated with exponential increases/decreases (ibid.). In a balancing loop the cycle in which the effect of a variation in any variable propagates through the loop and returns to the variable a deviation opposite to the initial one. In the case of a balancing loop the result contradicts the initial assumption and balancing loops have an odd number of negative links and associated with reaching a plateau. When identifying reference behavior patterns the identification of reinforcing and balancing loops is an important step (ibid.).

### Stock and flow diagrams

After the use of CLD to visualize a system's structure, behavior and analyzing the system qualitatively, a more detailed quantitative analysis is needed, which is done by transforming the CLD to a stock and flow diagram. Utilizing a stock and flow model helps to study and analyze the system in a qualitative way – these models are usually build and simulated using computer software (Wikipedia, 2015:4).

There are six elements of the stock and flow diagram: *stocks*, *flows*, *converters*, *connectors*, *sources* and *sinks* (Business Prototyping Blog, 2015:1).

- **Stocks:** represents a part of a system whose value at any given instant in time depends on the systems past behavior. The only way to calculate the value of a stock is by measuring how it changes at every instant and adding up all these changes. It is therefore not possible to determine the value of the stock at a particular instant in time by measuring the value of the other parts of the system at that instant in time (ibid.).
- **Flows:** represent the rate at which the stock is changing at any given instant, where they either flow into a stock (causing it to increase) or flow out of a stock (causing it to decrease) (ibid.).
- **Converters:** they either represent parts at the boundary of the system or they represent parts of a system whose value can be derived from other parts of the system at any time through some computational procedure (ibid.).
- **Connectors:** show how the parts of a system influence each other, much like in CLDs. Stocks can only be influenced by flows, flows can be influenced by stocks, other flows, and by converters. Converters are either not influenced at all, or are influenced by stocks, flows and other convertors (ibid.).
- **Source/Sink:** stocks that lie outside of the models boundary, used to show a stock is flowing from a source or into a sink that lies outside the models boundary, these are represented by small clouds in the diagrams (ibid.).

This technique visually distinguishes between the parts of the system and what causes them to change. It also allows for precise – quantitative – specification of all the system's parts and their interrelation, and provides a basis for simulating the behavior of the system over time (ibid.).

### Simulation

The real power of system dynamics is applied through simulation. The steps involved in a simulation are (Wikipedia, 2015:4):

- Define the problem boundary
- Identify the most important stocks and flows that change these stock levels
- Identify sources of information that impact the flows
- Identify the main feedback loops
- Draw a CLD that links the stocks, flows and sources of information
- Write the equation that determine the flow
- Estimate the parameters and initial conditions. These can be estimated using statistical methods, expert opinion, market research data or other relevant sources of information
- Simulate the model and analyze the results (ibid.).

The simulation model is a mathematical model, where stocks and flows are represented by integral equations and converters are represented by functions of their input and/or time. These integral equations cannot be solved analytically in most cases, but instead are approximated using numerical integration (Business Prototyping Blog, 2015:2). I will explore SD simulation more in depth in my research approach section, looking at the equations I wish to use when simulation my model. It is important to note that the equations developed will carry a lot of uncertainty in terms of reality, due to the limited possibility to get real time data from the different cases. However, when applying a SD approach one is usually more interested in the general patterns of behavior rather than with precise numbers. I also argue that the general patterns are highly important when modeling a business model for the IoT ecosystem, as this environment is highly dynamic and the numbers are likely to be very unpredictable.

### Model validation in system dynamics

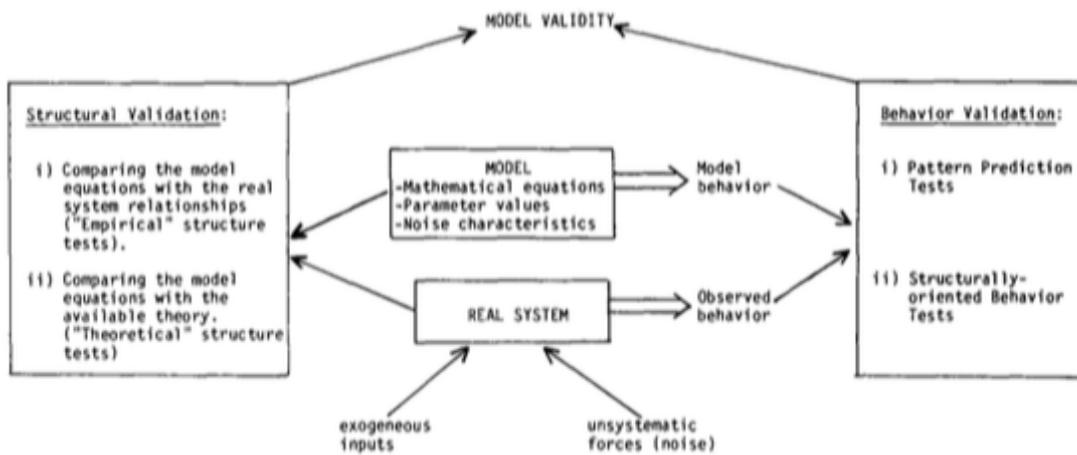
Model validation is an important step in the SD approach. The results of a given study's validity are crucially dependent on the validity of the model. The definition of model validation may be "*establishing confidence in the usefulness of a model with respect to its purpose.*" (Barlas, 1994:2). There are however no single established definition of model validity and validation in the modeling literature (Barlas, 1996:183). SD has in particular been criticized for relying too much informal, subjective and qualitative validation procedures. Barlas (1996:183, 184) argues, "*Model validity and validation in any discipline have to have semi-formal and subjective components for several reasons often discussed in system dynamics. An important reason have to do with the relationship between the validity of the model and its 'purpose'*". According to Barlas (1996:184) "*once validity is seen as "usefulness with respect to some purpose", then this naturally becomes part of a larger question, which involves the "usefulness of the purpose" itself*". When judging the validity of a model it is therefore important to judge the validity of the purpose too, this is essentially a non-technical, informal, qualitative process (ibid.). It is a gradual process to build confidence in the usefulness of a model, the process is dispersed throughout the methodology, starting with identification of the problem, and continuing even after implementation of policy recommendations. It is impossible to define the prolonged nature of model validation as an entirely technical, formal, objective process, as an analyst may spend more effort on the quality of the model in the model conceptualization and formulation phase, and therefore naturally spend less effort in the "formal" validation stage of the methodology, or vice versa (ibid.).

Validation of simulations models in SD consist of two types of validity test (Barlas, 1989:59):

- 1) *Structural* validity test, which function is to check whether the structure of the model is an adequate representation of the real structure (ibid).
- 2) *Behavior* validity test, which function is to check if the model is capable of producing an acceptable output behavior (ibid.).

Figure 3.1 shows how the two types of test are related to SD model validity. The figure shows that direct structural validation is typically achieved in two parts (Barlas, 1989:60): "*(i) By comparing the model*

equations with the real system relationship ('empirical' structural validation) and (ii) by comparing the model equation with available theory ('theoretical' structural validation)". The behavior validation consist similarly of two parts (ibid.): "(i) Test for 'behavior validation prediction': These test try to determine whether the behavior patterns generated by the model are close enough to the major patterns exhibited by the real system. (ii) Behavior test that are 'structurally oriented':By examining the model behavior under different conditions, these test try to determine whether there is a major error in the 'structure' of the model" (Barlas, 1989:60). Testing of the four types of validity must be utilized in a certain logical order. The model must first pass the *structural* test, then the *structurally oriented prediction* tests. This is due to the fact, that unless we are confident that a SD model is structurally sound, there is no point in testing it for pattern prediction ability (ibid).



**Major aspects of SD model validation (Barlas, 1989:60)**

The essence of a simulation model lies in its ability to represent and identify the casual relationships in the actual system accurately. If the relationships in the conceptual/qualitative model are inaccurate the insights and recommendations generated from the simulation model would be misleading (Quadrat-Ullah, 2011:160). The '*right structure for the right behavior*' is core for the validation process (ibid.). Forrester and Senge (1990) identified 17 tests, which illustrates the breath of channels for building confidence in system dynamics models, as shown in the table below. The table summarizes the tests of model structure, behavior, and policy implications. However, not all test are necessary, and Forrester and Senge (1990) have therefore identified "core tests for system dynamics", which is based on the test that accomplished system dynamicists generally rely on (Forrester & Senge, 1990:226).

**Confidence-building test (Forrester & Senge, 1980:227)**

<b>Test of Model structure</b>	<ol style="list-style-type: none"> <li>1. Structure Verification*</li> <li>2. Parameter Verification*</li> <li>3. Extreme Conditions*</li> <li>4. Boundary Adequacy*</li> <li>5. Dimensional Consistency*</li> </ol>
	<ol style="list-style-type: none"> <li>1. Behavior Reproduction* (system generation,</li> </ol>

<p style="text-align: center;"><b>Test of Model Behavior</b></p>	<p>frequency generation relative phasing, multiple mode, behavior characteristics)</p> <ol style="list-style-type: none"> <li>2. Behavior Prediction (patterns prediction, event prediction, shifting mode prediction)</li> <li>3. Behavior Anomaly*</li> <li>4. Family Member</li> <li>5. Surprise Behavior</li> <li>6. Extreme Policy</li> <li>7. Boundary Adequacy</li> <li>8. Behavior Sensitivity*</li> </ol>
<p style="text-align: center;"><b>Test of Policy Implications</b></p>	<ol style="list-style-type: none"> <li>1. System improvement</li> <li>2. Changed-behavior Prediction*</li> <li>3. Boundary Adequacy</li> <li>4. Policy Sensitivity*</li> </ol>

*\*Core test*

As structured tests are intrinsically part of constructing a system dynamics model, these are all included in core tests. The extreme condition test is heavily relied on as a means for identifying faulty hypotheses. The most utilized test of the behavior tests is the behavior reproduction test, the behavior anomaly, and the behavior sensitivity test (Forrester & Senge, 1990:226). When testing a model’s policy implications, change behavior prediction and policy sensitivity tests are essential. The core tests are marked with asterisk (\*). It is important to note that not all tests are possible or cost-effective to conduct in the confidence building test table, however the accessibility of the whole testing process is crucial to possibilities for success in system dynamics modeling (ibid.:226, 227).

### **Appendix D: The Target Hack**

The hacking of Target is known as the biggest retail hack in U.S. history, even though it was not particularly inventive. Someone had installed malware in Target’s security and payment system, in days prior to Thanksgiving 2013. The malware was designed to steal every credit card used at the company’s 1.797 U.S. stores. When consumers swiped their credit card when buying something at the store, the malware would step in and capture the shopper’s credit card number and store it on a Target server, which had been hijacked by the hackers (Riley et al., 2014).

The company had begun installing a \$1,6 million malware detection tool made by the security firm FireEye (FEYE) prior to the attack. FEYE’s consumers include the CIA and the Pentagon. Target had a team of security specialist in Bangalore to monitor its computers around the clock, notifying Target’s security operations center (SOC) in Minneapolis if anything suspicious was noticed (ibid.).

As the hackers uploaded exfiltration malware to move the stolen credit card numbers FEYE spotted them. The data was first moved to staging points spread around the U.S. to cover their tracks before ending up in the hackers computers in Russia. But Bangalore got an alert and flagged the security team in Minneapolis. But from here nothing happened (ibid.).

According to Target it was first after the U.S. Department of Justice notified the retailer about the breach in mid-December that the company's investigators went back to figure out what happened. In the meanwhile, the hackers had been able to steal 40 million credit cards numbers. The alarms of FEYE alarm systems had gone off early enough for the breach to be stopped, but the lack of activity from Target's own SOC allowed the breach to happen seamlessly. The outcome of this has been more than 90 lawsuits filed against Target by customers and banks for negligence and compensatory damages. The estimated cost could run into the billions as well as the loss of their customers' trust. In an attempt to win this trust back Target promised that consumers would not have to pay any fraudulent charges stemming from the breach (ibid.).

Target has since reported that the initial intrusion into its system was traced back to network credentials that were stolen from a third party vendor. The vendor in question was later identified as a refrigeration, heating and air conditioning subcontractor (HVAC system provider) that has worked at a number of locations at Target and other top retailers, according to sources. Using the stolen network credentials the hackers first broke into Target's network around two weeks before the attack. Due to this fact this represents an IoT breach, as IoT technologies (HVAC system) was the main reason this attack happened in the first place (ibid.).

The question has since then been why Target would have given an HVAC company external network access, or why that access would not be cordoned off from Target's payment system network (ibid.).

This again has fueled the discussion of network security and the importance of a competent SOC, where security awareness is key. The hack paints a picture of the lack of readiness within the IoT ecosystem, and highlights the importance of segmenting one's network when IoT devices are introduced into the environment. It is not enough to invest millions in security tools if the company's employees do not know how to use these tools. Especially retailers, whose main focus is on selling, often forget the importance of investing in SOCs and network security. Even though the stolen credentials of a third party vendor originally caused the breach, the responsibility lies with Target. It was the company's responsibility to segment their network, so the point of sale (POS) system was not connected to the rest of Target's network. Furthermore the lack of activity from Target's SOC was a critical factor for the breach to even happen.

Target has since then hired more than 300 people in their SOC, which is a tenfold increase since 2006 (Riley et al., 2014).

## Appendix E: Turber et al.'s application of DSR for developing the IoT business model artifact

Activity	Method & Evaluation	Outcome
<p><b>A 1</b> Outlining the problem situation</p>	<p>Method/Stimulus: Real-world BM workshops with companies revealed the difficulty to visualize, develop and analyze business models in IoT driven business environments with extant BM approaches.</p> <p>Evaluation:  <ul style="list-style-type: none"> <li>BM workshops in various industries, e. g. heating (5/13), home security (6/13), smart lighting (6/13), mobility (8/13), industry 4.0 (8/13), smart city (11/13) etc.</li> <li>Literature review, review with researchers (IS, Management sciences), interview with practitioners (strategy, C-level)</li> </ul> </p>	<ul style="list-style-type: none"> <li>Clear design objective: A "BM for IoT context"</li> <li>Justified research gap of high relevance</li> <li>Preliminary assumptions on artifact requirements</li> </ul> <p>Status: done (see: 1 Intro)</p>
<p><b>A 2</b> Analyzing extant research for ideas and definition of solution requirements</p>	<p>Method:  <ul style="list-style-type: none"> <li>Review of extant research at the intersection of management sciences, marketing and information systems research</li> <li>Review of extant business model approaches</li> <li>Derivation of requirements from theory</li> </ul> </p> <p>Evaluation: Cross-check w. experts and practitioners, test w. simple real-world IoT-business model instances (Nest)</p>	<ul style="list-style-type: none"> <li>Relevant research streams identified, i.e. (1) IS: Digitized objects research; (2) BM research; (3) S-D logic</li> <li>Justified artifact requirements</li> </ul> <p>Status: done (see: 3 Background)</p>
<p><b>A 3</b> Prototyping solutions &amp; testing in practice</p>	<p>Method:  <ul style="list-style-type: none"> <li>Prototyping by employing design principles [12] as interdisciplinary research team (IS, Strategy Management et al)</li> <li>Several times: Testing and revisiting prototypes of the new artifact through 1. multiple case studies (cases: BM of startups and incumbents in the IoT context, in the smart home and smart city context specifically. 2. Action research: Business model workshops in IoT context (smart city)</li> </ul> </p> <p>Evaluation: As part of each testing. Evaluation criteria equals the criteria in A5</p>	<ul style="list-style-type: none"> <li>Validated artifact instances, in particular in smart home and smart city context</li> </ul> <p>Status: done (see: 4 Artifact)</p>
<p><b>A 4</b> Proof-of-concept demonstration of the applicability of the proposed framework</p>	<p>Method:  <ul style="list-style-type: none"> <li>Action research: Cross-industry BM workshop with several companies, which are ecosystem partners, i.e. startups and incumbents in the overarching IoT context. Ideal: Wide range of industries represented</li> </ul> </p> <p>Evaluation:  <ul style="list-style-type: none"> <li>Equals evaluation in A5</li> <li>By expert and practitioners</li> </ul> </p>	<ul style="list-style-type: none"> <li>Validated artifact instance in the overall IoT context</li> </ul> <p>Status: <input type="checkbox"/> planned in 2014</p>
<p><b>A 5</b> Summary evaluation</p>	<p>Method:  <ul style="list-style-type: none"> <li>Semi-structured interviews with BM workshop participants after cross-industry workshop (A 4).</li> <li>Review with experts from research and practice</li> <li>Analysing</li> </ul> </p> <p>Evaluation: Structured evaluation according to following sets of criteria  <ul style="list-style-type: none"> <li>Set 1: to evaluate DSR process by Hevner's Guidelines</li> <li>Set 2: to evaluate DSR output (artifact)</li> </ul> </p>	<ul style="list-style-type: none"> <li>Field tested, actionable and justified artifact, ready to use for and researchers and practitioners.</li> </ul> <p>Status: <input type="checkbox"/> planned in 2014</p>
<p><b>A 6</b> Communication</p>	<p>Method: Four levels of communication  <ul style="list-style-type: none"> <li>Academic conference / journal contributions (IS, Strat. Mgt)</li> <li>Articles in practitioners outlet</li> <li>Workshop concept to operationalize &amp; apply the BM artifact in firms</li> </ul> </p> <p>Evaluation:  <ul style="list-style-type: none"> <li>Feedback of wider IS research and BM community</li> <li>Feedback by practice partners</li> </ul> </p>	<ul style="list-style-type: none"> <li>Peer reviewed publications</li> </ul> <p>Status: ongoing</p>

**Appendix F: Previous developed IoT business model for the thesis**

