Master Thesis

"Internet of Things as key driver for Business Model Innovation"

Name, Prename:	Caro, Nadav
Email address:	Nadav.caro@hhl.de
Study program:	P9 MBA
Chair:	Entrepreneurship and Technology Transfer
Supervisor:	Prof. Dr. V. Velamuri, Schumpeter Junior Professorship in Entrepreneurship & Technology Transfer

Berlin, August 1th 2015

Table of Contents

Tables list:

Abbreviations list:

BMI - Business Model Innovation

IoT - Internet of Things

M2M - Machine-to-machine

PSS - Product Service Systems

VP - Value Proposition

VCA - Value Chain Architecture

VC - Value Capture

1 Introduction

Competitive advantage is a principal element in corporations efforts to preserve or improve its market position. Traditionally, competitive advantage was achieved mainly through product innovation. However, participating in this endless innovation race bares significant risks. First, massive resources are needed in order to stay ahead of the competition. Many of the resources are consumed upfront, long time before the first dollar will be earned. Second, the revenue stream and the return on investment are uncertain. Last, nimble competitors can copycat the once innovative product, eroding any differentiation and writing off the hard labor and precious resources invested in the product development (Porter 1998, pp. 17–18; Amit, Zott 2012, pp. 41–42). A quote from an anonyms CEO reveals how fragile a competitive advantage which is based on product innovation is: “You are always one innovation away from getting wiped out by a new competing innovation” (Amit, Zott 2012, p. 43).

Nowadays, in order to stay competitive, companies have to adapt and innovate in every dimension. Mere product and process innovations are seen as insufficient. The new business conditions require companies to change their whole way of doing business (Chesbrough 2007, p. 12). Therefore, an increasing number of firms are opting for gaining a competitive advantage through Business Model Innovation (BMI). The attractiveness of BMI stems from numerous reasons:

- BMI often captures a undervalued source of future value, overlooked by the industry
- BMI often creates a sustainable differentiation from the competitors, as it is harder to replicate a well-designed, complex system of processes and activities than it is to reverse-engineer a single product
- Robust BMI typically creates a strong “lock-in” effect as the product is deeply embedded in an eco-system which offers a suite of additional services that yields a great portion of the product’s value. The “lock-in” effect raises the switching costs substantially, which in turn significantly reduced the chances of substitution

- BMI mitigates the risk of economic slowdown as the revenue stream is often generated not only by selling the product but also by providing additional reoccurring services
- BMI often has superior returns over product innovations, as it introduces a comprehensive eco-system and interacts with interdisciplinary market segments. Further, products tend to yield low-margin profits in comparison to services and especially to services which can be scaled easily and rapidly (namely IT-based services)

  (Teece 2010, pp. 179–181; Amit, Zott 2012, pp. 41–42; Lindgardt et al. 2009, pp. 2–4; Johnson et al. 2008)

In the light of these merits, it should come as no surprise why according to a survey conducted by the Economist Intelligent unit among senior executives, “the majority (54%), favored new business models over new products and services as a source for future competitive advantage” (Amit, Zott 2012, p. 41).

Internet of Things refers to physical devices that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. The Internet of Things extends internet connectivity beyond traditional devices like laptop computers and smartphones to a diverse range of devices and everyday things that utilize embedded technology to communicate and interact with the external environment, all via the Internet.

“Internet of Things (IoT) can be realized in three paradigms - internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge). Although this type of delineation is required due to the interdisciplinary nature of the subject, the usefulness of IoT can be unleashed only in an application domain where the three paradigms intersect” (Gubbi et al. 2013, p. 1649; Vermesan, Friess 2013, pp. 7–8). Therefore, in contrast to others technologies, IoT systems are innovative not because of a single innovative component in the system.

Instead, the innovation is drawn from the broad synergism of processes, devices, data and the interconnectivity with other systems (systems of systems).

Ongoing developments across the entire IoT stack (devices, connectivity and Data storage and processing) made IoT solutions affordable, feasible and capable than ever before. Breakthroughs in CPU design and production processes yielded smaller, cheaper, more powerful and efficient devices. Further, as IoT technology matures and commoditizes, prices of devices are dropping sharply accelerating the introduction of advanced sensorial technologies to the mass-market. In addition, improvements in communication technologies continues such as LTE, Bluetooth LE and more, enabling deploying IoT systems in new scenarios and supporting IoT penetration to new market segments. Finally, the rise of distributed computing systems designs, along with the development of novel machine learning algorithms, big data analytics and other IT-based technologies, resulted in smart, data-driven ubiquitous, proactive and autonomous IoT solutions (Porter, Heppelmann 2014, pp. 68–69; Uckelmann et al. 2011, pp. 97,131,209-213; DaCosta 2013, pp. 95–97).

The magnitude of change imposed by IoT solutions is colossal. In a connected world, products are no longer one-and-done. First, new features and functionality can be pushed over-the-air to customers. Second, the aggregated capabilities of an IoT system to ubiquitously sense, control, optimize and eventually be autonomous offer a fundamental change in the way corporations execute their business (Hui 2014; Porter, Heppelmann 2014, pp. 69–72; Uckelmann et al. 2011, pp. 5–9; Vermesan, Friess 2013, pp. 39–50; DaCosta 2013, pp. 131–139). In fact, the capabilities and merits IoT technologies offer are so fundamental that it is seen as the fourth industrial revolution (General Electric 2012, pp. 26–27; Bosch 2014, p. 3). “Machines that talk, machines that react, machines that constantly update their status - it sounds a bit like a social network... of machines” (Gertner 2014).

In a nutshell, IoT connects non-physical objects such as data and services to physical things, such as sensors and actuators. The true novelty of IoT solutions and their robustness, stem from the broad synergism of elements and processes.

Thus, IoT technologies, with a plethora of avant-garde capabilities, can be a strong driver for BMI in corporations. (Fleisch et al. 2014, p. 16). With the right BMI at hand, IoT can disrupt many traditional industries and introduce novel innovations in various market segments (Chui et al. 2010, p. 9; Gertner 2014, p. 9; Fleisch et al. 2014; Danneels 2004, pp. 247–250; Porter, Heppelmann 2014, pp. 72–76).

This study focuses on how IoT can serve as a driver for BMI in corporations and what characterizes an IoT-based BMI. In order to address this main question, four research questions have been tested:

- Question 1: How does IoT affect the Value Proposition (VP)?
- Question 2: How does IoT affect the Value Chain Architecture (VCA)?
- Question 3: How does IoT affect the Value Capture (VC)?
- Question 4: How does the firm is opting and implementing IoT-based BMI?

This study will address these questions by researching the theoretical background of business model innovation, as well as by performing interview-based, case study analysis of five companies from various industries:

- Cisco - Technology/Networking & Communication Devices
- General Electric - Industrial goods
- Accenture - Technology/Information technology services
- DriveNow - Transportation
- RWE - Utilities/Electricity & Gas

In addition, a general conversion about IoT was held with Professor Sanjay Sarma from Massachusetts Institute of Technology (MIT), in order to get a better and wider perspective of the IoT domain.

Apart from the introduction section, this study is compiled from the following sections:

- Section 2 - Theoretical framework
- Section 3 - Research design and case studies
- Section 4 - Findings
- Section 5 - Cross-case analysis
- Section 6 - Discussion and conclusions

2 Theoretical Framework

Famous BMI success stories, such as Apple, Southwest Airlines and Nespresso, have showcased that with the right product at hand and with a solid business model built around it, companies can introduce disruptive changes to traditional industries, topple incumbent companies and even define and shape a brand new market segment. (Amit, Zott 2012, pp. 42–44; Teece 2010, pp. 177–179; Porter 1998, pp. 11–25).

The importance of the business model and the potential of BMI did not elude the eyes of researchers and practitioners. “Business-model innovation is critical to success in today’s increasingly complex and fast-changing environment" (Giesen et al. 2010, p. 17). Numerous surveys and studies have emphasized the potential of BMI and the priority and attention it receives from top executives. In a study conducted by IBM (2008), 98% of the CEOs interviewed stated that their company would undertake extensive (69%) or moderate (29%) business model innovation within the following three years, emphasizing the increased importance of BMI to business (Uckelmann et al. 2011, p. 257). However, although BMI has strategic implications to corporations and despite the surge in academic publications about BMI and business models, surprisingly, there is no single common definition of what a business model is.

According to Chesbrough (2010, p. 355), a business model has the following principal functions:

- Articulates the value proposition
- Identifies a market segment
- Defines the structure of the value chain
- Details the revenue mechanism
- Estimates the cost structure and profit potential
- Describes the position of the firm within the value
- Formulates the competitive strategy

In their journal article, Johnson et al. (2008, pp. 52–53), defined business model as a combination of four elements: Customer Value Proposition, Profit Formula, Key Resources and Key Processes.

Teece (2010, p. 179) concluded that the essence of business model is “about the benefit the enterprise will deliver to customers, how it will organize to do so, and how it will capture a portion of the value that it delivers”.

The causes for a missing coherent definition for a business model was analyzed by Zott et al. (2011, p. 1020), which argued that “researchers frequently adopt idiosyncratic definitions that fit the purposes of their studies but that are difficult to reconcile with each other”. However, the researchers also managed to find a common ground between the various business model definitions:

“Business model is a new unit of analysis that is distinct from the product, firm, industry, or network; it is centered on a focal firm, but its boundaries are wider than those of the firm; (2) business models emphasize a system-level, holistic approach to explaining how firms “do business”; (3) the activities of a focal firm and its partners play an important role in the various conceptualizations of business models that have been proposed; and (4) business models seek to explain both value creation and value capture.”

Based on some of the most cited studies in the field of BMI (Chesbrough 2010; Zott et al. 2011; Amit, Zott 2012; Teece 2010) this study will define BMI as a composition of three distinctive elements:

1. Value Proposition (VP)
2. Value Chain Architecture (VCA)
3. Value Capture (VC)

2.1 Value Proposition

Teece (2010, p. 174) suggested that “a good business model yields value propositions that are compelling to customers, achieves advantageous cost and risk structures, and enables significant value capture by the business that generates and delivers products and services.”

Uckelmann et al. (2011, pp. 257–258) defined value proposition as “what is actually delivered to the customer. This goes beyond the product or service offered. It describes which customer needs are satisfied and details what other quantitative (e.g., price or speed of service) and qualitative aspects (e.g., brand, design, cost/risk reduction) contribute to the offered value”. In the IoT context the authors consider “raw data about physical objects as well as any aggregated or processed information a core component of the value proposition.”

IoT systems, with their ubiquitous sensing, data gathering, big data analysis and sophisticated algorithms, enable companies to monitor, control and optimize processes whilst significantly increasing automation level along the entire value chain of the business (Vermesan, Friess 2013; Uckelmann et al. 2011). Moreover, IoT offers, for the first time, real-time, high resolution monitoring of large-scale distributed assets (Chui et al. 2010; Hui 2014). In addition, IoT enables innovative business models, such as Product as a service (PaaS) and Sensor as a service (SaaS), which can serve customers’ needs in a more suitable fashion. (Fleisch et al. 2014; Gubbi et al. 2013).

According to Kyriazis, Varvarigou (2013), the technology-rich digital environment of IoT solutions enable the provision of added-value applications that exploit a multitude of devices, contributing to services and information. Moreover, as technology matures, emphasis will be shifted to approaches that allow devices and systems to become smarter, more reliable, and more autonomous.

Uckelmann et al. (2011, p. 266) argues that apart from controlling and optimizing processes, “end-user integration through data provision and end-user programming as well as the implementation of autonomous services will take the

Internet of Things to the next level, where the Internet of Things is more than a pure B2B infrastructure."

In sum, by adding new features and capabilities to existing products, by bundling services with products, by introducing connected-born novel devices and by introducing brand new business model concepts, IoT can significantly improve the value proposition of products and services to the customers.

2.2 Value Chain Architecture

What connects and drives the different elements of an IoT-based system is the flow of Information, its analysis and the actions taken based on the analyzed data. This is a crucial observation, as data can be used repeatedly by various stakeholders without degradation in quality and value (Uckelmann et al. 2011; Hui 2014; Chui et al. 2010). Hui (2014) also refers to the data-driven fundamental change in the ecosystem and in the value chain of connected products. According to him, robust data gathering and information sharing between various stakeholders and connectivity between various products and systems can form the base for innovative services.

The report of the German National Academy of Science and Engineering (acatech 2013, p. 32) about Industry 4.0, the implementation of IoT in the industrial segment, emphasizes that IoT can "serve to create horizontal value networks at a strategic level, provide end-to-end integration across the entire value chain of the business process level, including engineering, and enable vertically integrated and networked design of manufacturing systems."

Chaouchi (2010) emphasized IoT as a driver for value chain innovations, as new object-to-object based services will be introduced, removing humans from the direct decision making processes.

The vision of the new connected world in the era of IoT depicts a world in which the entire value chain is fully connected end-to-end. Along this value chain,

information is shared between the various stakeholders. This harmonious automated interconnection along the entire value chain improves processes, fosters innovative value propositions and maximizes value creation (acatech 2013; Uckelmann et al. 2011; Fleisch et al. 2014).

In sum, the robust capabilities of IoT will enable to streamline, optimize, predict and automate value-chain processes. These groundbreaking capabilities for managing existing businesses will shake the traditional value chains of many industries. Moreover, IoT will form the basis for innovative business models that were unfeasible before. Further, transferring and sharing information across the entire value chain will enhance the collaboration between the various stakeholders whilst forming the basis for new alliances, aiming to supply additional services and products in order to capture additional value.

2.3 Value Capture

Hui (2014) holds that “making money in the connected space is not limited to physical product sales; other revenue streams become possible after the initial product sale, including value-added services, subscriptions and apps, which can easily exceed the initial purchase price.”

Porter, Heppelmann (2014, p. 35) noted that as connected products are not one-and-done any more, “companies can diagnose product performance, problems and failures and sometimes make repairs remotely, reducing reliance on service partners. By minimizing the role of the middlemen, companies can potentially capture new revenue and boost margins.”

Uckelmann et al. (2011, p. 264) hold that information is a key driver for generating diversified revenue streams in IoT systems. Further, the authors assert, “separated billing capability for physical products and information, and thus a decoupling of information and product prices, will enable new business models”.

To conclude, any robust IoT-based BMI should be opted for generating revenues by providing a comprehensive solution that combines products as well as services. Moreover, the constant collection of raw data and the information drawn from its analysis, enable the offering of additional value-added services (e.g. consulting, benchmarking and optimization). In that aspect, IoT can function as the principal driver for transferring a product-based company to a product-services-system (PSS) provider, which typically improves the company's market position as well as the its financial performance (Velamuri et al. 2013)

3 Research Design and Case Studies

3.1 Research design

Although the IoT concept was introduced two decades ago, the technology is still evolving and the use-cases are still being explored, developed and deployed. Thus, the number of large-scale, field-proven implementation of IoT systems is still relativity limited. As a result, research on BMI in the IoT domain is scarce as well. Therefore, an exploratory, qualitative-driven research approach was selected as the core research method of this study (Eisenhardt 1989).

In addition, the qualitative research method offers some advantages over the quantitative research method. First, the qualitative research method fosters the development of a theory even when relatively little information in known about the topic under research. Second, the method enables factoring the unique, context-dependent factors of the case under study, which are typically lost in the blur of big quantitative data analysis methods (Yin 1984). Third, by opting for multi-case based research, the qualitative research method fosters not only the analysis of a single, standalone case but also the analysis of diversified, various cases (Eisenhardt 1989). Exploring the phenomenon under study from different perspectives and in different contexts allows various facets of the phenomenon under study to be revealed while emphasizing the differences, the commonalities and the relationships within and between the cases (Baxter, Jack 2008). These merits of the qualitative research method yield a more profound and compelling understanding of the phenomenon under study, resulting in a more robust research outcome (Yin 1984; Eisenhardt 1989; Firestone 1993).

In line with the multiple case study research method and as presented in the introduction section, interviews were conducted with five senior executives from five different companies, representing various industries. Additional data was gathered from available public sources such as companies' websites, articles, public interviews and more.

Each interview commenced by presenting the goals of the research and the research method. Then, numerous open-ended introduction questions were asked in order to better understand the company as well as the interviewee position, knowledge and experience. Further general questions were asked about the utilization of IoT in the firm, in order to determine the adaptation level of the technology.

Next, a set of open-ended questions was asked about each of the three business model elements: value proposition, value chain architecture and value capture. Additional set of open-ended questions queried how the firm opted for investing in IoT and how this decision was executed.

Concluding the interview were numerous open-ended questions addressing the interviewees' personal view of the future of IoT and reviewing limitations, risks and obstacles, which are relevant to IoT.

Following each interview, an in-depth within-case analysis was conducted in order to reveal significant findings and in order to search and highlight cross-case common patters (Yin 1984). By constantly referencing the cases to the theoretical framework developed in section 2 and by reviewing the results of the within-case and cross-case analysis, a general theory was developed, shaped and refined (Eisenhardt 1989).

3.2 Case Studies

3.2.1 Cisco Systems

Cisco is mostly recognized for its wide range of communication-related hardware products. However, the company is in the midst of a strategic shift towards new more lucrative domains such as data centers, cloud computing and security. In addition, cisco is rapidly expanding its services and solutions portfolio in order to offer innovative value-added services as well as to foster a holistic approach for the design, deployment and utilization of its products and services. The company serves businesses of various sizes, public institutions and organizations and individuals. Cisco was founded in 1984 and is headquartered in San Jose, California.

Cisco is developing, manufacturing and selling IoT devices as standalone products as well as embedded devices in comprehensive IoT solutions. Moreover, Cisco recognized the potential of selling add-on services, such as security, optimization, and consultancy, on top of its hardware products. Thus, the company is heavily investing in expanding and diversifying its products and services offering. The firm already sells full-scale IoT solutions for various industries and sectors such as mining, healthcare and more. Cisco perceives cloud technologies, security services and IoT as the key strategic growth drivers of the company.

3.2.2 Accenture

Accenture provides management consulting, technology, and business process outsourcing services worldwide. Accenture’s incorporated headquarters is situated in Dublin, Ireland since September 2009. It is the world's largest consulting firm by revenues.

Accenture’s core competences are strategy, integration and IT consulting. IoT solutions are typically comprised of these competences, making it a perfect match for Accenture’s core business. The company sees IoT as a game-changer to many

segments it is active in. Accenture has a unique cross-industry overview of IoT as it serves a highly diversified clientele.

The company is heavily involved in the IoT domain in order to improve and strengthen its current services and in order to develop new ones. The company is examining a wide variety of IoT products and solutions in order to master the technology, examine usage scenarios, and establish partnerships and position itself as a leading IoT consultancy firm.

3.2.3 General Electric Company (GE)

GE is a mega-conglomerate comprised of numerous divisions that offer wide range of products and services. The company core businesses are healthcare, transportation, aviation, power and water, oil and gas and industrial IT solutions. The company was founded in 1892 and is headquartered in Fairfield, Connecticut.

Advanced technology is a core competence of GE and stands in the heart of every segment the company is operating in. Moreover, the company sees in its technology the most important factor for competitive advantage and market supremacy. GE is developing IoT devices and software solutions for its existing line of businesses in order to improve control, enhance performance, increase automation and offer innovative services.

Although GE is mainly recognized for its industrial goods, about 70% of its profit is already coming from services. The company sees in its relatively new software division a strategic driver for future growth. IoT is perceived as a prime driver for offering a wide range of software-based value-added services. Predix, GE's software platform for Industrial Internet applications, is the main effort of the firm to penetrate and capture market share in the industrial internet segment.

3.2.4 RWE AG

RWE is a German utilities company headquartered in Essen, North Rhine-Westphalia. Through its various subsidiaries, RWE supplies electricity and gas to more than 20 million electricity customers and 10 million gas customers across Europe.

RWE is utilizing IoT along parts of its value chain, from power production, through distribution and grid management. In addition, the company is selling IoT-based smart home equipment to its customers.

The firm sees IoT as principal driver for shifting from its traditional, centralized power generation to the novel, distributed power generation. Further, IoT is perceived as one of the main drivers for diversifying RWE products and services portfolio.

3.2.5 DriveNow GmbH

DriveNow is a joint venture of BMW and Sixt that provides car sharing services in several cities in Europe and North America. DriveNow service began in Munich, Germany in June 2011. As of November 2014, the company operates over 2,400 BMW and Mini vehicles, which serve seven cities worldwide and over 330,000 customers.

IoT systems form the backbone of DriveNow infrastructure. From both the customer and the company perspectives, the entire value chain of DriveNow is driven by IoT generated data. The company is levering BMW Connected Drive system in addition to proprietary equipment to track the status and the location of the cars as well as to interface with the customers. The data generated by the DriveNow cars enable the company to service the fleet efficiently and promptly.

Without IoT, it would have been impossible to operate such a complex system. Hence, DriveNow is a perfect showcase for an IoT solution as a business enabler.

Table 1: List of interviewees

Company	Annual turnover	Number of employees	Interviewees (years employed in firm)
CISCO	$47B	70,000	1. Senior Vice President, Internet of Things + GM Sports and Entertainment Business & IOT, Internet of Things Global Sales (20 years)
accenture	$32B	323,000	1. Director, Open Innovation and Venturing Strategy (3 years)
GE	$149B	305,000	1. Head of industrial internet R&D center (10 years)
RWE The energy to lead	$48B	60,000	1. Innovation & Cooperation (10 years)
DriveNow	N/A	N/A	1. IT executive manager (2 years)

4 Findings

A thorough analysis of the case studies reveled significant impact of IoT on all business model components: value proposition, value chain architecture and value capture. Further, with such a profound impact on all business model components IoT was acknowledged to be a key driver for business model innovation.

4.1 Value proposition

4.1.1 Product offering

IoT fosters a wide variety of innovative products and services and substantially enhances existing ones.

Cisco now offers full-stack IoT solutions for various segments. At the heart of these solutions stand various IoT technologies, which enable full digitalization of the business. For instance, Cisco's innovative IoT solution for mines enables the operators in a remote control room to monitor employees, machinery, assets and infrastructure such that they can better asses, plan and direct the work in the mine. Moreover, the solution elevates the safety level of the mine and enables benchmarking the individual mine performance versus other mines operated by the company and against industry standards. Cisco executive elaborates about introducing additional, data-driven services, which yield additional value, on top of the company's traditional line of products:

> "The value we deliver in understanding and delivering and supporting very scalable, very reliable, very secure global networks is a serious base differentiator. We're also not standing still and believe there is a layer of value add above the basic connectivity layer which obviously first have to deliver security. But then, in network analytics, network location-based services, networks value-add - so using the network information to understand where you are as a person or where you are as an asset, where you are going and therefore analyzing flow analyzing energy consumption can be a huge value extracted from the network".

Accenture describes the potential impact of IoT solutions on conservative segments such as insurance and banking as no less than a revolution. For instance, by constantly tracking and monitoring the insured assets, insurance companies can issue policies that are personally tailored and vary based on the insured assets actual utilization profile. This will make the current statistics-based insurance policies obsolete, as they will prove to be much less accurate. Moreover, IoT based insurance can diminish the moral-hazard issues that traditional statistics-based insurance policies bare. Further, the lending business of the finance industry worked in the same way for centuries. Utilizing IoT in the finance industry can lead to a dramatic change in the way loans are issued and managed. By connecting to existing IoT systems or by deploying new ones at the debtor premises, creditors can gain a real-time, unbiased, transparent overview on the debtor operational status, dramatically reducing the risk, as it diminishes the need to rely mainly on post-ante aggregated financial reports.

In addition, Accenture is also testing IoT technologies that will enhance its capabilities in its traditional consultancy business. For instance, the company is testing smart employee tags, which enable to automatically map the unofficial network structure of an organization, enhancing Accenture's ability to provide accurate consultancy services.

DriveNow operates thousands of cars and serves hundreds of thousands of customers in seven cities worldwide. DriveNow executive emphasized the importance of IoT to the DriveNow service: "Internet of things powers part of DriveNow operations". Elaborating on that, IoT enables the company to track its assets location and condition and to dispatch assistance or scheduled maintenance in case it is needed. Customers can view real time information about the cars (type, position, condition and more) and to book them. The entire customers' experience, from booking, through driving and billing is working seamlessly. Without IoT, it would have been unfeasible to develop, deploy and operate such a complex and sophisticated product.

RWE executive described the momentous value proposition shift the company is undertaking:

> "…One of the largest value propositions that we are currently redefining is our business model of producing electrons and then sending them to people's houses where they use them - that's the business model of the past. Now that is changing obviously because photovoltaic especially are coming on to the rooftops of the people, which means they will not need the centrally generated electricity. So the value proposition of the future will be to maximize the value of electros that people produce at their own homes"

This strategic shift in RWE value proposition is being propelled by IoT technologies. IoT facilitates connecting, controlling and managing the large number of distributed energy producers. In addition, RWE aims to offer insurance policies to private electricity producers, guaranteeing them reliant energy supply from the main grid in case their equipment fails or in case of environmental conditions such as cloud overcast or lack of wind hamper electricity production.

RWE IoT-based smart home products offer customers superior convenience, security, accessibility and efficiency. RWE executive elaborated about the company's vision in the smart home domain:

> "RWE wants to be a "pain killer" in the future. We want to identify pain people have in their everyday life and we want to offer a service that actually alleviate and limits that pain. We want to base this on our existing position in the smart home, in the electric vehicle and in the photovoltaic expertise that we already have – we want to leverage that more in the future."

4.1.2 Cost reduction

Increasing efficiency and productivity was a prominent topic among interviewees working for industrial companies.

Many of GE's products are already equipped with a wide variety of sensors. GE is offering optimization services that are based on the data generated by these products. By constantly monitoring, analyzing and tweaking the software of the component, a significant cost reduction can be achieved. GE executive commented on that:

> "Aircraft engine generate megabytes of data every second and terabytes of data every day…. Now if you just use analytics you can actually improve the fuel efficiency of the engine by one, two, maybe more percentages…. If you could do that to one engine, and every aircraft has two or four engines and you have a whole fleet of, say fifty maybe a hundred or two hundred aircrafts - this is a big deal! And we're just talking about algorithms of software, not doing anything to the engine itself".

Another crucial aspect is the ability to predict and recognize an impending problem in mission-critical equipment. By alerting on a potential failure before it happens, GE can offer its customers better equipment utilization with substantially less unplanned downtime. This is extremely important when dealing with equipment such as turbines, locomotives and jet engines, in which a failure can lead to catastrophic results.

Accenture holds that IoT will change the way most of the industry are utilizing their assets and it sees a vast potential for cost savings. For instance, Accenture is testing how IoT can help improve efficiency in gas and oil industry. One of the most resource intensive tasks in this domain is examining and servicing a complex network of pipelines. Currently, the existing methods are based mainly on pre-scheduled work plan. Accenture is testing solutions in which sensors, unmanned vehicles, drones and maintenance workers will work in collaboration such that sensors and unmanned assets will monitor and test the pipelines while maintenance workers will services the assets on demand. This solution can dramatically reduce the costs, as human workforce will be deployed only when and where it is needed, whilst sensors and unmanned assets will perform the daunting task of constantly monitoring and examining the infrastructure.

DriveNow is leveraging BMW Connected Drive system to preemptively service cars that reported issues such as low fuel, low battery charge and more. By dispatching Sixt maintenance teams to service these cars, in a just-in-time manner, the overall costs is reduced and the availability and utilization of the fleet rises. Additionally, BMW and DriveNow are utilizing the big data collected across the DriveNow fleet to improve efficiency and reduce malfunctions. DriveNow executive commented about BMW Connected Drive system utilization:

> "We are using the Connected Drive events so if you are driving and, for example, running out of oil then there's kind of oil warning that you see in car. And we also see that on the other side so operational events are triggered by the car itself."

4.1.3 Superior customer experience

DriveNow is using IoT system across its entire value chain. The tight integration between the cars, the IT infrastructure, the maintenance teams and the users enable the company to provide a seamless customer experience and introduce novel features and services.

RWE facilitates IoT to manage its electricity grid, offering more stable electricity supply with greater availability and assurance to its millions of customers.

Cisco executive elaborated on the potential of delivering a superior customer experience:

> "…I have a beautiful refrigerator that every time I open it up there is a little light flashing at me, telling me I should replace the filter. Well, if the manufacturer could send me a text and say that the light is flashing because your filter does not only needs replacing but because the filter is not working your energy consumption on that device has just gone up thirty percent. The next thing they don't want you to do is they don't want you get it on Amazon and put any filter in there. They want you to replace it with their filter. So if they could send you another text to say click on this link and we will dispatch you exactly the filter you need and will get it in a timely manner and you'll get

a warranty on it. You know, me as a consumer, my experience goes up because the company that sold me that product is delivering more value."

4.2 Value chain architecture

4.2.1 Compacting the value chain

Increased efficiency yields a more compact and effective value chain with less intermediaries and manual processes.

Cisco executive sees IoT as a major driver removing or bypassing intermediaries along the traditional value chain:

> "…If you can connect to your tools, to your machines, and to your customers in a whole different way and you can provide a better service - that is phenomenally disruptive to your existing business model because maybe you relied on third party like a retailer or a value added reseller and they do a great job for companies. But, you know, they're not as committed to you as a single company as they are to the various products they represent on their shelves".

RWE executive commented that IoT results in more automation, replacing manual labor and streamlining the traditional value chains. The executive highlighted how IoT impacts the value chain:

> "If you utilize data from all of these new things that are going online in the future, then you cut significant cost out of your value chain. And you actually enable automatic procedures and things as predictive maintenance before it becomes too late. So I think IoT changes the value chain significantly "

Accenture executive commented on what the company is forecasting for parts of the traditional value chains:

> “In some ways it collapses the value chains, because it makes the transactions between the production and consumption points a lot shorter with fewer intermediaries”.

4.2.2 Expending the value chain

Partnerships and alliances are key drivers for creating additional value on top of the traditional value chain.

Cisco is forming partnerships in order to penetrate the industrial internet domain through collaboration with market leaders. Cisco executive commented on the strategic partnership with Rockwell automation:

> “Rockwell automation is 125 year old industrial player. They realized that this disruption is happening and we don't have all the answers but we're rolling our sleeves up together and trying to figure this out as we go along and it's a very profitable high growth partnership for us”.

The same executive also testified about the importance of its ecosystem to the company:

> “Our ecosystem and our partner community is probably the best in the world. We've been committed to our partner ecosystem for many many years. And even in tough times we have not gone direct or cut out our channel. And we believe that is a huge multiplier for us. That gets us exposed to the other parts of the solution and other parts of innovation, and therefore Cisco's build buy partner model really has kept us in good stead decade after decade”.

GE launched a software division in order to develop core competences that will form the base for novel services. GE’s crown jewel in the software division is a platform named Predix, which will enable third parties to develop and deploy apps on top of its systems. GE executive described the expectations from the new software division, which expends GE traditional value chain:

> “The profits generated just by analytics products is going to grow… We are going to see credit streams from services. Eventually, at the end of the day the expectation is that it is going to generate a multibillion dollars business”.

DriveNow is a joint venture between BMW, which manufactures and equips the cars and develop the IT solutions, and Sixt that operates and services the cars and the customers. Both companies are using DriveNow as a testbed for technologies and ideas.

4.2.3 Innovative value chain architectures

IoT fosters new value chain architecture that was impossible to develop, implement and operate beforehand.

DriveNow innovative value chain architecture is powered by IoT. It enables the company to introduce a disrupting business model to the relatively traditional transportation segment. Moreover, when autonomous cars will be available, DriveNow will be able to leverage its business model even further. The company can base its fleet on autonomous cars in order to offer superior transportation solution to its customers whilst increasing efficiency by utilizing advanced optimization and automation across the firm’s operations.

IoT is a central element is RWE push to support decentralized electricity producers. IoT enables RWE to connect a large number of distributed electricity producers whilst stabilizing the power grid, assuring a stable supply of energy for all the customers.

Accenture is testing solution in which drones are operated autonomously and in collaboration with service teams to check assets such as mobile towers, and oil and gas pipelines.

4.3 Value capture

IoT fundamentally changes the way companies are capturing value. The findings in this section are tightly coupled with each other. In sum, the findings suggest that IoT transfers product oriented companies to service vendors. By doing so, companies can improve their profit margin, gain more stable cash flow from long-term reoccurring services, diversify their revenue sources and monetize a greater portion of the eco-system.

4.3.1 Diversifying revenue sources

Cisco IoT solutions supports the company's traditional business lines as the company is selling more hardware, whilst selling higher margins reoccurring services such as security, data analytics and cloud services. The executive noted on the diversity of revenue sources:

> "You look at the layers of value you can capture. There's a basic connectivity market that's pretty good. …Secondly, we can organize connectivity in more of the solutions consumable way. Thirdly, you can analyze that connectivity and extract more data to drive more value. Therefore, you can offer services that help people understand and help people extract that data. And then we have even invested in a thin layer of highly trained consultants because we truly believe there's a market opportunity to roll our sleeves up with customers that, you know, would value our perspective."

DriveNow enables BMW to diversify its revenue sources, to expose potential customers to its products, to increase brand visibility, to improve company's image across the broad public and to sell cars to a market segment that did not exists before. Sixt extends its leasing and rental business by servicing the DriveNow fleet. Moreover, as Sixt already holds the competence of servicing large fleets with high efficiency, servicing the DriveNow fleet maximizes the merits of economies of scale even further.

Although GE is perceived as product oriented company, the company actually produces 75% of its profits from services (including the GE finance division – N.C). This strategic shift can be dramatically accelerated by IoT. As many of GE products are already IoT enabled, the company is developing services that will leverage the data generated by these products and yield additional value to the user. Moreover, the company is developing a platform that will enable third party applications to interface with GE products. This will enable GE to capture greater revenue from each product sold, as the company is generating revenues from selling the product, from servicing it and from offering data-analytics solutions.

4.3.2 Improve profit margins

In general, services and especially software-based scalable services record higher profit margins in comparison to physical goods. GE executive commented about the firm's software division profit margins: "The Profit margins of software are very very high – not like making a locomotive."

Cisco executive elaborated about how IoT is improving the profit margins:

> "This is a very margin rich territory because once they're adding a lot more value, then there's a consultative angle to it. There is a services angle to it so by nature those are more high value than basic connectivity. But even in the connectivity world certain areas of this market are low end and therefore come with sort of a degree of commodity margin and commodity pricing but in areas (such that…) security is a key, global scalability is a key, accuracy of tracking of assets is a key - I do believe that there's a value premium there. I'm confident that it's going to help the margin mix and profitability of actually any business model, if you can move up the value stack. There is a phrase, in the absence of value everything is purchased on price."

4.4 Opting and implementing IoT

All the companies are operating R&D centers, which test and develop IoT technologies. The organizational structure of the firms changed in line with the maturity and readiness of the technology and the relevant solutions. For instance, Cisco is already operating a separate IoT business division. GE is operating its IoT business as part of its software division.

GE, Accenture and Cisco all emphasized their eco-systems, which are comprised of alliances and partnerships with other companies. The companies also highlighted the constant search for potential M&A targets, especially startups with the potential to disrupt entire market segments, but also mature companies that can diversify and expand the solutions portfolio.

Accenture executive described their activity in in the IoT domain:

> "Accenture open innovation interacts with the innovation ecosystem- startups, universities, trying to identify players that could be relevant to global enterprises and try to partner with them sooner."

In addition, Accenture executive also explained the motivation behind the firm's pursue of IoT:

> "Industrial Internet is a major step towards digitization of the industry. Accenture is an IT and a strategy company combined. So to summaries, industrial Internet will transform the business of our clients through massive digitization and we are the heart of it because we are company that understands technology and strategy."

GE executive commented on how GE started to focus on IoT:

> "GE R&D centers, called Global Research, along with others have done some analysis and they have realized that the value of data and analytics is important. They went to Jeff Immelt, the CEO, and recommended we start

looking at that (industrial internet –N.C). It started a process in the company which eventually led to the creation of GE software division."

GE executive describes the investments and collaborations activity of GE through his current and previous roles:

"My team focused on scouting for external innovations, which means identifying companies that GE either invests in or partner with or buy. We focused on all areas of GE portfolio: health care, energy, software cyber security. We now have a portfolio of about ten companies that GE invested in and more than twenty partnerships and agreements that we created. And now, one of the first steps is to expand capabilities by starting startups acceleration program".

Cisco executive talked about which various information sources pushed the company to opt for IoT:

"You know he (John Chambers, Cisco Ex-CEO – N.C) meets with a lot of government officials and leaders around the world. He has an amazingly good sense and access to a lot of data points around the world including educational institutes and innovation labs and so. The culmination of research on what is being connected and how it's being connected, a lot of customer feedback about what they expect and what they need from the network and combining that with some of the innovation we had going together, we realized that connecting the unconnected could drive more value".

The same executive also commented on the motivation behind Cisco's decision to invest in innovation centers around the world:

"You can never underestimate how fast the world is changing and how much innovation is going on out there and what the startup community is. So what we've done is to open eight innovation centers around the world to partner up with the innovation and the startup community".

DriveNow was founded on the base of the fruitful cooperation between BMW and Sixt. None of the companies had the core competences required for successfully launching this kind of operations. Hence, the two companies opted for leveraging the tight collaboration and their individual core competences and spin off a joint venture. DriveNow executive commented on BMW and Sixt decision to spin off the DriveNow joint venture:

> “Sixt and BMW have always had very close relationships and car sharing was coming. Sixt had already had a car sharing thing before which was not so successful - they had few failure experiences. BMW, at least at that time, was not so much into direct consumer relations. So they figured out to build a joint venture and go for it.”

For both companies, DriveNow functions as vibrant test bed for features, technologies and processes. DriveNow executive commended on this:

> “Sixt is able to gain knowledge and experience from the next generation of car rental technology, including Internet of things capability, and the same goes for BMW. They can test and develop technology which they can then bring into more serious production”.

5 Cross-case analysis of IoT in light of business model innovation

Based on the information gathered on how IoT is affecting the firm's business model, the next section focuses on common patterns emerging from the analysis of the various case studies.

GE CEO described the colossal strategic shift the industry is experiencing:

> "If you went to bed last night as an industrial company, you are going to wake up in the morning as a software analytics company. The notion that there is a huge separation between the industrial world and the world of digitization and analytics software – those days are over!" (General Electric 2014)

The main common motivation to invest in connected products is the understanding that the generated data has an immense, uncaptured value for the customer as well as for the equipment manufacturer. GE executive stated the following concerning the value of the data:

> "…In the past we used to rely in our business model on selling equipment and services. But now, with this equipment being able to generate data, with all the devices being connected, the real value is in the data analytics that this equipment provides".

Indeed, the study's most significant observation is that data analytics is the prime driver behind the strategic shift of firms pivoting their business model from low profit margin products to more lucrative software-driven services. Hence, it should come as no surprise that product-oriented companies are all aiming to produce and deliver connected-born devices and convert existing offline devices to connected ones. This colossal strategic shift projects fundamental changes on companies' core competences, value proposition, value chain architecture and revenue generation

Regarding value proposition, connecting products to the internet means that the connection between the company and the customer is maintained long time after the purchasing transaction occurred. Based on the generated data from the distributed devices, companies are offering value added services aimed to help their customers increase operational efficiency and reduce costs. For instance, an equipment vendor can recommend altering the utilization method of the product, based on patterns emerging from customer' utilization data. Additionally, the vendor can notify the customer when an impending malfunction is about to happen and dispatch a service team with the relevant training, tools and spare parts to address the issue. Handling impending malfunctions preemptively significantly reduces unplanned downtime, which reduces costs. In addition, it increases assets availability and utilization, which increases revenues. For instance, GE fits its locomotives with multiple sensors that transmit huge amounts of data on performance level. Based on collected information and on big data, analysts can recognize an impending problem, schedule a train for service, and get a part ready to install, averting a breakdown on the tracks.

Further, companies can now remotely and automatically repair malfunctions, which often occur due to software issues, by deploying over the air (OTA) software updates. Moreover, the functionality of the devices can be enhanced by introducing new features through software updates. One prominent showcase for that is Tesla, which constantly adds features and enhances the performance of the cars by dispatching software updates. Additionally, deploying connected born devices enable unique products and services offerings, which were unfeasible before. For instance, DriveNow is a good example for an IoT-driven service that is utilizing the sharing economy business model. In this case, IoT enables the company to offer product-as-a-service (PaaS), meaning the product, which is the car, is utilized as a pay-per-usage transportation service.

In regards to value chain architecture, by fully digitizing and connecting entire value chains, companies are able to further streamline and automate their processes, achieving supreme operational efficiency. Further, utilization of big-

data analytics along with real-time information transmitted from deployed devices, is transforming the servicing model of many industries from pre-scheduled maintenance to predictive, on-demand maintenance. This has a significant effect on the way companies are utilizing their assets and execute their processes, resulting in improved financial performance. GE CEO stated on the impact of IoT on the financial performance of companies: “Small changes drive massive impacts” (General Electric 2014).

Moreover, the generated data also functions as a main driver for expending the value chain architecture. By developing in-house core competences, by forming novel eco-systems and through collaborations, companies are extending their traditional value chains such that they do not revolve just around the physical product any more. Instead, companies are now offering holistic, data-centered solutions that include diversified value-added services such as maintenance, replenishment, optimization, and consultancy services. Cisco executive commented on the holistic solution approach: “we should no longer show up with a bag of tools. We should show up with the right bag of tools, organized in the right manner for the right industry”. By offering more services, a broader, richer value chain architecture is formed, generating and capturing more value from each product and from the data it produces. For instance, Cisco, which traditionally was focused on network equipment, is building in-house cyber-secure competence after concluding that cyber-security will be a prominent component in any IoT solution. Thus, it is strategically important for Cisco acquiring this capability.

Last, IoT enables full-scale digitization resulting in real-time, fine-grained autonomous value chains. The superior transparency, control and automation foster the creation of disruptive products and services that were impractical or even inconceivable before. In general, industries that experienced low penetration rate of fine-grain mass-digitization are the most prone to major business model disruptions. The following intriguing example was elaborated as a usage case for IoT by Accenture executive: insurance policies are traditionally assessed and priced according to a customer profile which is primarily comprised of statistical

data and available personal information. However, there is no possibility to offer a tailored solution that will be based also on individual on-going futuristic activities. By utilizing IoT, insurance companies can now asses their customer risk profile at real time and offer a more accurate and personalized insurance policy, substantially reducing their risk whilst lowering the insurance cost for truly risk-averse customers.

In regards to value capture, monetizing IoT propels a strategic paradigm shift in the way companies capture value. As the value proposition shifts from product-centric to data driven value-added services, companies reshape themselves as product-service-systems vendors (PSS). Instead of one-time transaction when selling a product, companies can now record a reoccurring stream of revenues from diversified value-added services. Depending on the product and on the industry segment, the revenue streams yielded by the services can last for a significant long time after the product was sold, dramatically changing the way companies are pricing their products and calculating customer life-time value. For instance, companies may choose to sell low profit margins products at cost or even at a loss, in order to secure a steady reoccurring stream of high-profit margins revenues, stemming from the additional services. Additionally, companies can “white label” their services and distribute them via other third-parties channels, enjoying economies of scale. For instance, GE is developing Predix, its software platform for the industrial internet. Predix is designed to service not only GE original equipment but other equipment manufacturers as well. Further, the platform will enable hosting third-party apps, capturing additional value through partnering with third-party software solutions vendors.

By introducing new services through building core-competence in-house, through collaboration and through outsourcing, companies can substantially diversify their revenues sources, yielding a more stable cash flow, improving profit margins and capturing a bigger value from the eco-system. For instance, RWE is diversifying its traditional revenue sources by utilizing IoT-enabled smart grids to service the private electricity producers segment.

Last, regarding the IoT adaptation process, all of the interviewed executives acknowledged the economic potential as well as the substantial technical merits of IoT. Further, they all perceive IoT as a key driver for disruptive changes across multiple industries. In general, companies see the huge potential for business model innovation and they are worried they will not be part of it when it realizes. Thus, it should come as no surprise why in all cases the decision to go after IoT and invest heavily in it came as a top-down strategic management decision - it forces a strategic shift in the mindset and in the core competences of the company.

Companies acknowledge the complexity of offering large-scale IoT solutions in term of the various core competences required to design, develop, deploy and operate such as solution. Thus, they all turn to found partnerships and eco-systems which synergize the stakeholders' core competences and cover competency deficiencies. For instance, GE partnered with Accenture to offer integration services, a core competence Accenture has but GE lacks, and a competence that is highly needed for designing and deploying complex IoT solutions.

Further, in order to assess IoT solutions, companies invest heavily in R&D centers that also function as innovation hubs for partnerships with other companies and startups. In general, all the interviewees mentioned the drive to create in house innovation. However, they were all fully aware that innovation might come from other companies or startups. With vivid examples of disruptive startups turned into multibillion businesses such as Uber, AirBnB and more, all interviewees mentioned mergers and acquisitions (M&A) as a significant activity. The M&A activity is primarily aimed at retaining competitive advantage as well as gaining additional core competences needed for offering IoT solutions. For instance, Cisco acquires numerous startup companies in the cyber security domain in order to establish cyber security as a core competence of the company.

Table 2: Shift in firms value proposition through IoT adaptation

Firm	Traditional value proposition	New value proposition
GE	We sell the most advanced industrial equipment in the world	We deliver superior value to our clients by delivering the most advanced industrial goods with novel data-analytics driven services
RWE The energy to lead	Producing electrons in centralized power plants and distribute them over the grid	• Maximizing the value of electrons produced by distributed electricity manufactures whilst providing them power from the main grid in case they cannot generate electricity. • Alleviate customers' "pain" by utilizing smart-home appliances and services
DriveNow	Not available. Service is not feasible without IoT	A to B flexible personal transportation through applying sharing economy business model
accenture	No significant impact on main value proposition. However, total addressable market (TAM) is much bigger as new segments become highly tech-savvy through IoT adaptation	
CISCO	Market leader in network equipment	Full stack solutions by offering advanced hardware and services and by utilizing its robust collaborative eco-system

Table 3: Shift in firms value chain architecture through IoT adaptation

Firm	Traditional value chain architecture	New value chain architecture
GE	Focus on R&D and manufacturing	• Extend value chain by offering through SaaS and PaaS solutions. • Significantly more post-sales interfaces with the customers • Collaborate with third parties in order to offer full stack solutions
RWE The energy to lead	Focus on producing and distributing electricity	• Focus on meshed smart-grid, connecting a plethora of small electricity producers • Collaborate with various companies in order to offer a holistic solution for the smart home domain
DriveNow	Not available. Service is not feasible without IoT	Data-driven, semi-automatic, fleet management
accenture	No significant impact on value chain architecture. Increased collaboration with companies seeking to penetrate new market segments through IoT utilization that requires Accenture's expertise.	
CISCO	Focus on R&D and manufacturing	• Extend value chain by offering through SaaS and PaaS solutions. • Significantly more post-sales interfaces with the customers • Collaborate with third parties in order to offer full stack solutions

Table 4: Shift in firms value capture through IoT adaptation

Firm	Traditional value capture	New value capture
GE	• Selling industrial goods and service the equipment sold • Services are tightly coupled with physical products	• Wide variety of data-driven services yield a stream of stable, long term revenue • Services as standalone products, also for non-GE products
RWE The energy to lead	Produce and sell as many electrons as possible	• Smart grid as a service for private electrify producers • Smart home products drive additional services
DriveNow	Not available. Service is not feasible without IoT	Product (car) as a service revenue model
accenture	No impact	
CISCO	• Selling mainly hardware products servicing it • Services are tightly coupled with physical products	• Wide variety of data-driven services yield a stream of stable, long term revenues • Services as standalone products, also for non-GE products

Table 5: Assessing the effect of IoT on the firms business model, in light of the research findings

Business model element	Findings	GE	RWE The energy to lead	DriveNow	accenture	CISCO
Value proposition	Product offering	High	Medium	High	Low	High
	Cost reduction	Low	High	Medium	Low	Low
	Customer experience	High	Medium	High	Low	Medium
Value chain architecture	Compacting the VCA	Medium	Medium	High	Low	Low
	Expending the VCA	High	Medium	Low	Medium	High
	Innovative VCA	Medium	Medium	High	Low	High
Value capture	Diversification	High	Medium	Medium	Low	High
	Improve profit margins	High	Medium	Low	Low	High

Table 6: Juxtaposing the theoretical framework to the case study analysis

Business model element	Theoretical position	Case study analysis	Conclusion
Value proposition	"Raw data about physical objects as well as any aggregated or processed information a core component of the value proposition" (Uckelmann et al. 2011)	GE executive: "…In the past we used to rely in our business model on selling equipment and services. But now, with this equipment being able to generate data, with all the devices being connected, the real value is in the data analytics that this equipment provides". GE CEO: "If you went to bed last night as an industrial company, you are going to wake up in the morning as a software analytics company. The notion that there is a huge separation between the industrial world and the world of digitization and analytics software – those days are over." "The value we deliver in understanding and delivering and supporting very scalable, very reliable, very secure global networks is a serious base differentiator. We're also not standing still and believe there is a layer of value add above the basic connectivity layer which obviously first have to deliver security. But then, in network analytics, network location-based services, networks value-add - so using the network information to understand where you are as a person or where you are as an asset, where you are going and therefore analyzing flow analyzing energy consumption can be a huge value extracted from the network".	Confirmed
		DriveNow, Cisco, RWE and GE executive all mentioned the potential of gaining superior customer experience through IoT utilization. This is achieved through seamless processes, through better product	New There were no

		utilization and through retaining a tight connection between the vendor of the equipment and the end-customer.	theoretical studies reviewing the effect of IoT on customers experience, although the change in company core competences is colossal and the potential financial gain is substantial
Value chain architecture	According to (Hui 2014), robust data gathering and information sharing between various stakeholders and connectivity between various products and systems can form the base for innovative services. What connects and drives the different elements of an IoT-based system is the flow of Information, its analysis and the actions taken based on the analyzed data. This is a crucial observation, as data can be used repeatedly by various stakeholders without degradation in quality and value (Uckelmann et al. 2011; Hui 2014; Chui et al. 2010).	Cisco executive: "…If you can connect to your tools, to your machines, and to your customers in a whole different way and you can provide a better service - that is phenomenally disruptive to your existing business model because maybe you relied on third party like a retailer or a value added reseller and they do a great job for companies. But, you know, they're not as committed to you as a single company as they are to the various products they represent on their shelves". Cisco executive: "Our ecosystem and our partner community is probably the best in the world. We've been committed to our partner ecosystem for many many years. And even in tough times we have not gone direct or cut out our channel. And we believe that is a huge multiplier for us. That gets us exposed to the other parts of the solution and other parts of innovation, and therefore Cisco's build buy partner model really has kept us in good stead decade after decade". GE's crown jewel in the software division is a platform named Predix, which will enable third-parties to develop and deploy apps on top of	Confirmed

		its systems	
	According to Chaouchi (2010), IoT functions as a driver for value chain innovations, as new object-to-object based services will be introduced, removing humans from the direct decision making processes. According to Hui (2014), robust data gathering and information sharing between various stakeholders and connectivity between various products and systems can form the base for innovative services.	RWE executive: “If you utilize data from all of these new things that are going online in the future, then you cut significant cost out of your value chain. And you actually enable automatic procedures and things as predictive maintenance before it becomes too late. So I think IoT changes the value chain significantly “ DriveNow executive: “Internet of things powers part of DriveNow operations”	Confirmed
Value capture	“Making money in the connected space is not limited to physical product sales; other revenue streams become possible after the initial product sale, including value-added services, subscriptions and apps, which can easily exceed the initial purchase price.”(Hui 2014) Uckelmann et al. (2011, p. 264) hold that information is a key driver for generating diversified revenue streams in IoT systems	Cisco executive: “You look at the layers of value you can capture. You know one let's not ignore that you know there's a basic connectivity market that's pretty good. …Secondly, we can organize connectivity in more of the solutions consumable way. Thirdly, you can analyze that connectivity and extract more data to drive more value. Therefore you can you drive services to help people understand and help people extract that data. And then we have even invested in a thin layer of highly trained consultants because we truly believe there's a market opportunity to roll our sleeves up with customers that, you know, would value our perspective.” GE executive: “The profits generated just by analytics products is going to grow… We are going to see credit streams from services. Eventually, at the end of the day the expectation is that it is going to	Confirmed

		generate a multibillion dollars business".	
	"Companies can diagnose product performance, problems and failures and sometimes make repairs remotely, reducing reliance on service partners. By minimizing the role of the middlemen, companies can potentially capture new revenue and boost margins."(Porter, Heppelmann 2014)	GE executive: "Aircraft engine generate megabytes of data every second and terabytes of data every day…. Now if you just use analytics you can actually improve the fuel efficiency of the engine by one, two, maybe more percentages…. If you could do that to one engine, and every aircraft has two or four engines and you have a whole fleet of, say fifty maybe a hundred or two hundred aircrafts - this is a big deal! And were we're just talking about algorithms of software, not doing anything to the engine itself". DriveNow executive: "We are using the Connected Drive events so if you are driving and, for example, running out of oil then there's kind of oil warning that you see in car. And we also see that on the other side so operational events are triggered by the car itself." Accenture executive: "In some ways it collapses the value chains, because it makes the transactions between the production and consumption points a lot shorter with fewer intermediaries".	Confirmed

6 Discussion and conclusions

The main aim of this master study is to research, deduct and conclude how IoT is functioning as a key driver for business model innovation. Particularly, this study focuses on depicting the impact of IoT on the various business model elements - value proposition, value chain architecture and value capture. As elaborated in section 3, this study is based on two pillars of data. First, a comprehensive literature review was held in order to lay the theoretical framework. Then, interview-based, case study analysis of five different companies from various industries was conducted. By juxtaposing the theoretical framework with the findings extracted from the case analysis, the study strengthens and further contributes to previously published research about IoT and its impact on business model innovation.

First, the study highlights the impact of IoT on the value proposition innovation, primarily by enabling new products, by reducing costs and by increasing reliability and availability. These findings are in line with the findings of Vermesan, Friess (2013), Uckelmann et al. (2011), Fleisch et al. (2014), Gubbi et al. (2013) and Kyriazis, Varvarigou (2013).

Furthermore, the study reveals the significant positive effect of IoT on customer experience. IoT enables companies to offer additional services that optimize the utilization of the product such that the customer is enjoying the best possible user experience. Despite the strategic implications of gaining superior customer experience, the impact of IoT on the customer experience is relatively an uncharted domain. There were only handful of studies that were primarily researching this issue, although it can function as a key driver for gaining competitive advantage and for creating differentiation. However, this value proposition is not coming for free. Companies which are not accustomed to service their clientele in a high touch manner, will need to invest massive resources and make a paradigm shift in the way they execute their business in order to develop superior customer experience as a core competence. Thus, I strongly believe that

further research can shed more light on the way companies should approach this issue and execute the transformation in an IoT-enabled world.

Second, the study emphasizes the importance of IoT to the value chain architecture. Equipping devices with actuators and sensors, meshing them all into one connected network and utilize robust data analytics result in significant merits. Levering on that, companies are better able to control, optimize and automate their processes, yielding a more efficient, streaming and compact value chain. This finding strongly supports the claims of Uckelmann et al. (2011) and Fleisch et al. (2014). Another paramount finding is that sharing data forms the foundation on which the value chain architecture can be expended. Based on the generated data, companies are developing new core competences and forming alliances and collaborations in order to provide additional services, expending their activities and stretching the boundaries of their traditional value chain. Expending the value chain architecture and building new core competences, whether in-house or through collaboration, proves to be the key driver for monetizing IoT. This finding strongly supports the findings of Uckelmann et al. (2011), Fleisch et al. (2014) and Kyriazis, Varvarigou (2013).

Furthermore, this study emphasizes the strategic role of IoT in enabling innovative value chain architectures that aim to disrupt traditional value chain architectures. IoT solutions enable, for the first time, full digitization of entire value chains. The outcome of this digitization is fine-grained, real-time monitoring, optimization and automation of processes at a colossal scale, which was inconceivable beforehand. This is in line with Chui et al. (2010) and Hui (2014) conclusions. Further, innovation in value chain architectures often fosters the introduction of innovative business models, such as in the case of DriveNow, Uber and Nest. Cisco IoT division manager had a striking observation on the impact of IoT on various market segments. He stated that the segments that are going to be affected the most by IoT are, surprisingly, the segments that currently have relatively low digitization level. In these segments, such as transportation, healthcare, utilities, insurance

and more, the merits of IoT solutions will be the driver for a quantum leap forward in term of business model innovation, as IoT will fully digitize these domains. In the more Tech driven segments, companies will more likely leverage IoT to hone their current business model, yielding incremental enhancements.

Third, this study strongly supports Uckelmann et al. (2011) assertion that data is a prime driver for generating diversified revenue streams from IoT systems. Based on the data generated by the IoT devices, additional value-added services can be offered, creating additional value that was not monetized beforehand. In general, as the additional services become more valuable to the customer, companies are transforming from traditional product-based vendors to product-service-system vendors (PSS).

In addition, the study strongly supports Hui (2014) and Porter, Heppelmann (2014) observation that in the connected world, revenues are no longer restricted to the single transaction of selling the physical product. Instead, revenue can be generated along the entire lifetime of the product by selling additional value added services on top of the physical product. This observation may dramatically alter the way companies are generating profits, as it might be more profitable selling a product at cost or even at loss, while securing a long-term service agreement which will compensate the lost earnings and generate a more stable and reoccurring revenue stream. Further, the transition to product-service systems (PSS) can improve companies' profit margins as it is typically more profitable selling software products and scalable services than it is to sell physical products, in line with Velamuri et al. (2013) findings. This conclusion has a strategic effect on the way sales and marketing divisions should function. It projects that the physical product is no longer the sole target of the advertising and sales efforts. Instead, companies should now market and serve a comprehensive solution, which is compounded from the product as well as the supplementary services.

Last, the study tracked how companies are opting and implementing IoT business models. In general, all the reviewed companies understand the strategic importance of IoT to their business. Thus, the decision to pursue IoT technology is coming from the top management as a strategic directive with massive resources allocated for this effort. Companies based their decision on various sources such as customers' requests, market analysis, connections with government agencies, in-house R&D centers and more. The main conclusion here is that, unsurprisingly, innovation will be presented by new startups as well as by market incumbents. The corporations, which are fully aware of the disruption potential, are terrified to miss the next wave of disruptive innovations and leg behind the competition, losing their market position. The impression is that each and every senior executive had the Kodak or Nokia downfall story in the back of his head - everyone wants to avoid it and emerge victorious from the next wave of disruptive innovations. Hence, In order to secure their supremacy, companies are relentlessly trying to identify hot trends as they evolve and acquire potentially disruptive startups as they gain traction. In order to achieve that, companies employ a wide variety of means. All the companies are heavily investing in R&D centers, collaboration initiatives, M&A and market research. The motive is keeping as many channels open as you can, in order to catch even the faint sound of a distanced disruptive change, so you will not be caught off guard.

The strengths of the current study must be tempered with recognition of its limitations. As described in section 3, the research method of this thesis is based on case study analysis. Out of the five companies that were reviewed for this paper, four are large-cap international corporations. Only one, DriveNow, can be described as a startup company. However, even DriveNow is not a classic startup company as it is a joint venture of BMW and Sixt. Innovation, and especially disruptive innovation, is often introduced by startups that aim to change the status quo and attack the incumbents. A vivid example is the impact of startups such as Uber and Airbnb on the transportation and accommodations segments, respectively. Thus, the lack of case studies on startup companies may lead to an incomplete understanding of IoT-based business model innovations. However, it is

worth highlighting that all the big corporations are operating R&D centers and innovation labs in order to assess new technologies and to keep an open eye on the vibrant startup scene. The interviewees were all well aware of the intense activity happening in the startup domain. Hence, I believe that the risk of missing a major finding due to lack of not interviewing startups representatives is significantly reduced.

Another limitation of this study stems from the fact that each case study is based on an interview with a single executive only. This negates the possibility of cross-checking data and may result in missing significant findings or using incorrect data which, in turn, may lead to wrong conclusions. However, all the interviewees are top executives, veterans in the IoT domain, and hold vast knowledge and experience on both the technological aspect as well as the business aspect. Furthermore, findings are based on the intersection of various individual answers from the different interviewees. Thus, the risk that stems from the lack of multiple sources per each case study is small.

On the technological aspect it is critical to emphasize the factors that may hinder or even prevent wide adaptation of IoT solutions. These factors, which are intertwine with each other, are namely security and privacy. Regarding security, connecting devices to the internet inevitably expose them to potential attackers. This is highly crucial and important when dealing with mission critical infrastructure and equipment. Additionally, as companies connect their entire value chain to the internet, they expose themselves to industrial espionage and sabotage which may grind a company's operations to a halt. Thus, it should come as no surprise why all interviewees mentioned security as a core competence for delivering IoT solutions.

With regards to privacy, contrary to public channels such as social networks and blogs that hold information the user generally intended to post, connecting sensors that constantly gather personal and private information, such as physical status, location, activity and more, jeopardizes our privacy even further as they reveal highly sensitive and personal information. As many of the IoT merits are based on

big data analysis, without ubiquitously collecting data these services will not be able to function effectively and efficiently.

Privacy and security concerns are not theoretical threats. Ongoing security and privacy incidents demonstrated how vulnerable and exposed our personal data is and how supposedly secured networks can be breached and tempered with. Thus, privacy and security threats are clear and present danger for both individuals and corporations. According to the RWE executive, all of RWE connected home products do not transfer personal information to RWE and only store data locally, within the consumer's domain. This is a vivid example how the fear from privacy violation is preventing large-scale utilization of IoT-generated data. Thus, failing to overcome the security and privacy hurdles might prevent a wide adaptation of IoT solution as corporations and individuals may consider the hazards to be more significant than the merits.

When confronted with the privacy and security concerns, all the interviewees responded to the issue in the same manner. They all agreed that it is a real threat but they all argued that the threats are manageable and that the benefits of IoT are greater by far than the threats it introduces. This claim is backed by the fast growth of companies such as Google and Facebook, which offer their services for free, while harvesting and utilizing the users' personal data in order to sell targeted advertisements with great success. The rise of these companies demonstrates that a greater portion of the population is willing to relinquish some privacy in order to get services for free. However, in regards to that manner, it is advisable to remember a phrase coined by Andrew Lewis: "If you are not paying for it, you're not the customer, you're the product being sold".

Epilogue:

The concept of IoT is about 15 years old. However, it is only in recent years that connected products became widely available. The main trigger for this sudden change was shrewdly recognized by Cisco executive:

> "…There's mass proliferation of sensor technology which, as you know shrunk in size, gone up dramatically in compute power but also is now almost available at a disposable price point so the sensors are more readily available than ever been before."

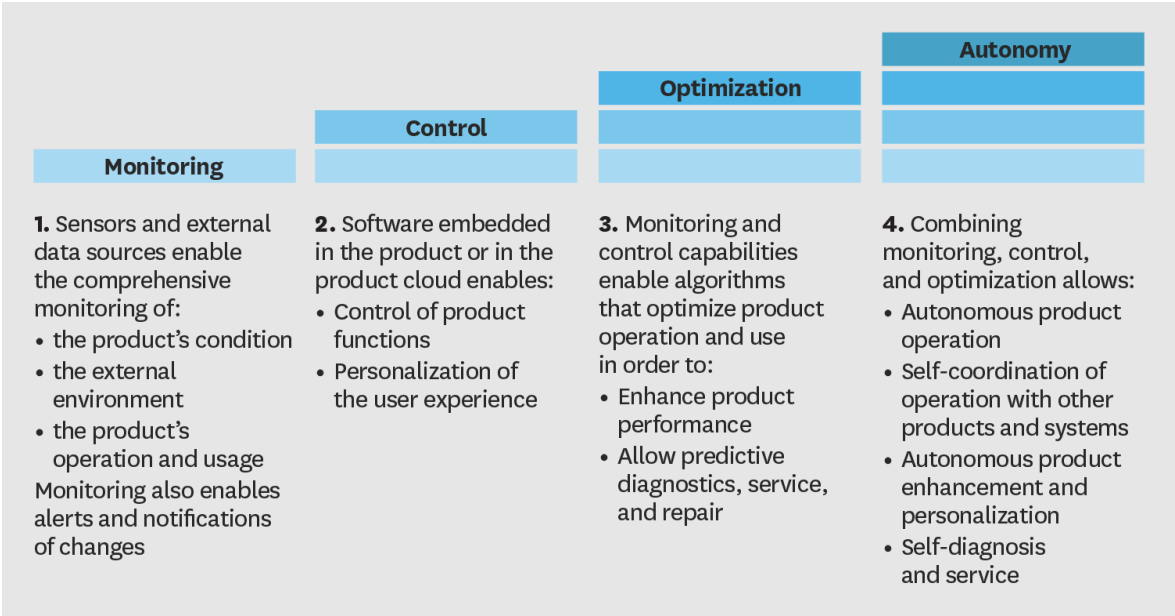
Indeed, there is a convergence of maturing technologies across the entire IoT stack (devices, communication and knowledge), which led to the maturing of IoT solutions, making them readily available for broad market penetration. Moreover, future advancements in each of the stack levels will continue pushing IoT further by introducing novel features and by enabling deployment of IoT solution in new scenarios and domains.

The introduction of the internet and later on the introduction of the smartphones had affected every soul on earth and each and every industry. IoT enables to further revolutionize segments that were not intensively interrupted by the internet and mobile revolution. As IoT-enabled devices are getting commoditized, IoT solutions are becoming more affordable. From smart power wall socket, through Smart City management and a 24/7 personal health monitoring, we are going to encounter IoT everywhere. Thus, without no doubt, as IoT continues to evolve and mature, we will experience a slew of IoT-based innovative products and services, resulting in a dramatic change in the business environment landscape and in the way we live our lives.

7 Appendices

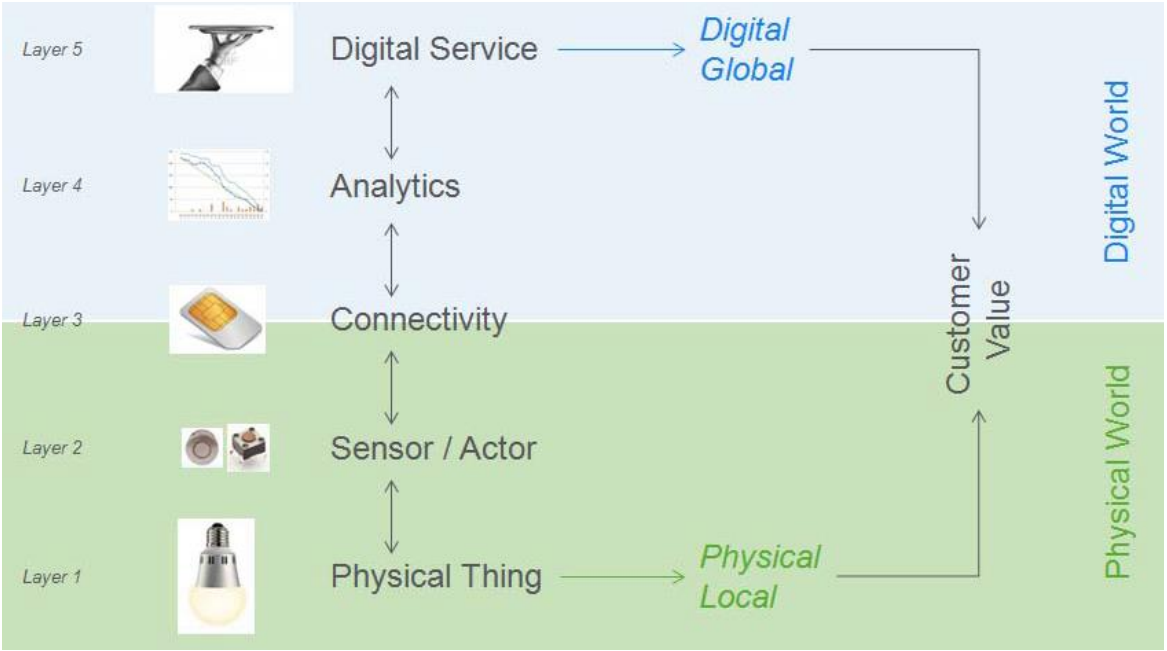
Appendix I: Capabilities of Smart, Connected Products

Source: Porter, Heppelmann 2014



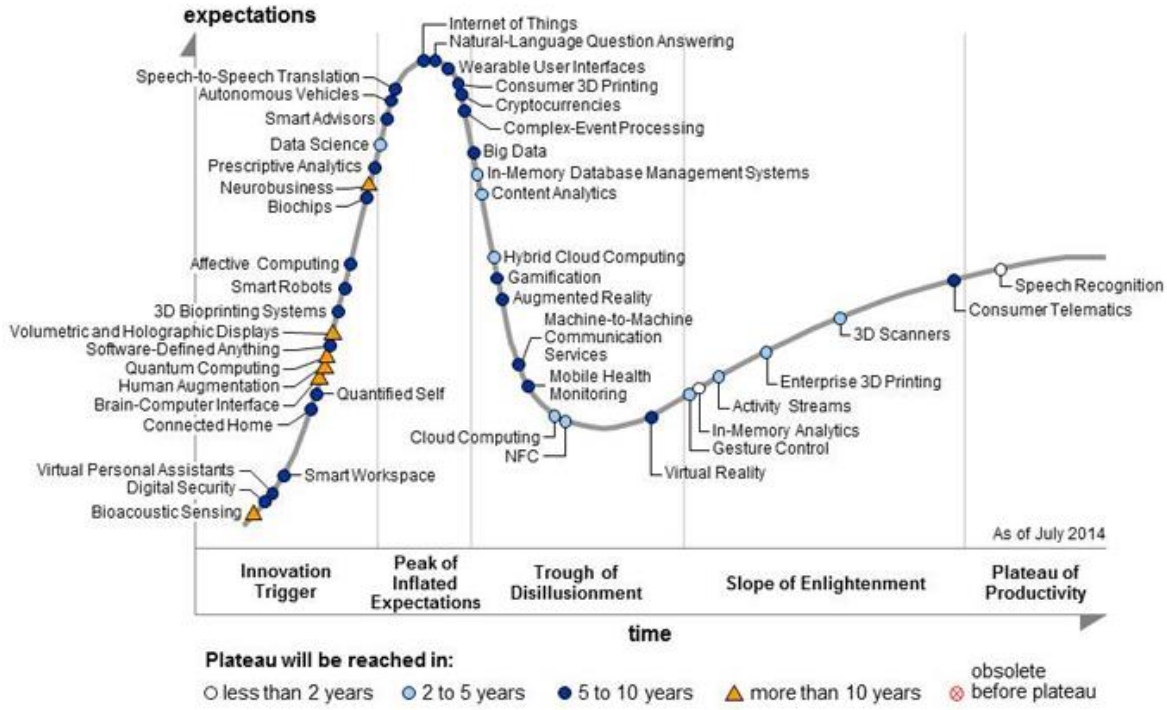
Appendix II: Value-creation Layers in an Internet of Things Application

Source: Fleisch et al. 2014



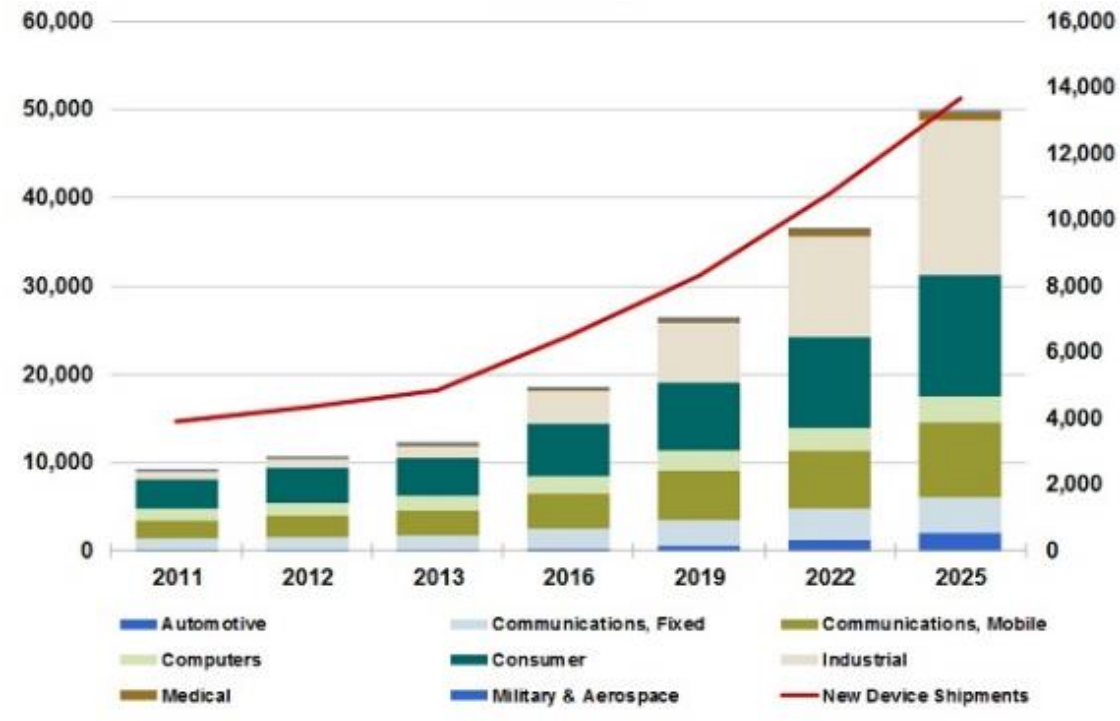
Appendix III: Hype Cycle for Emerging Technologies, 2014

Source: Gartner



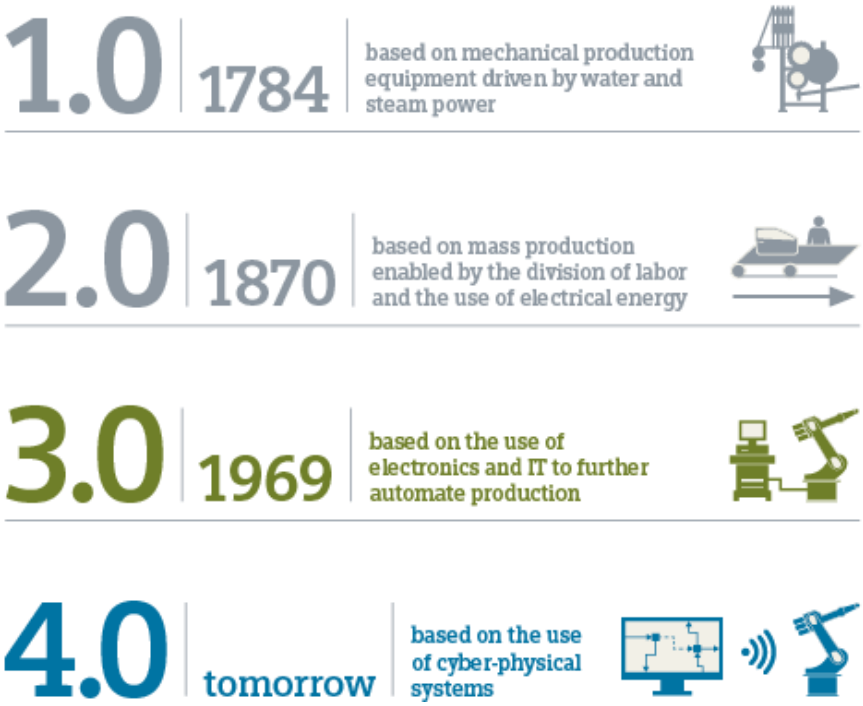
Appendix IV: Connected Devices Market Size (in millions)

Source: HIS Inc.



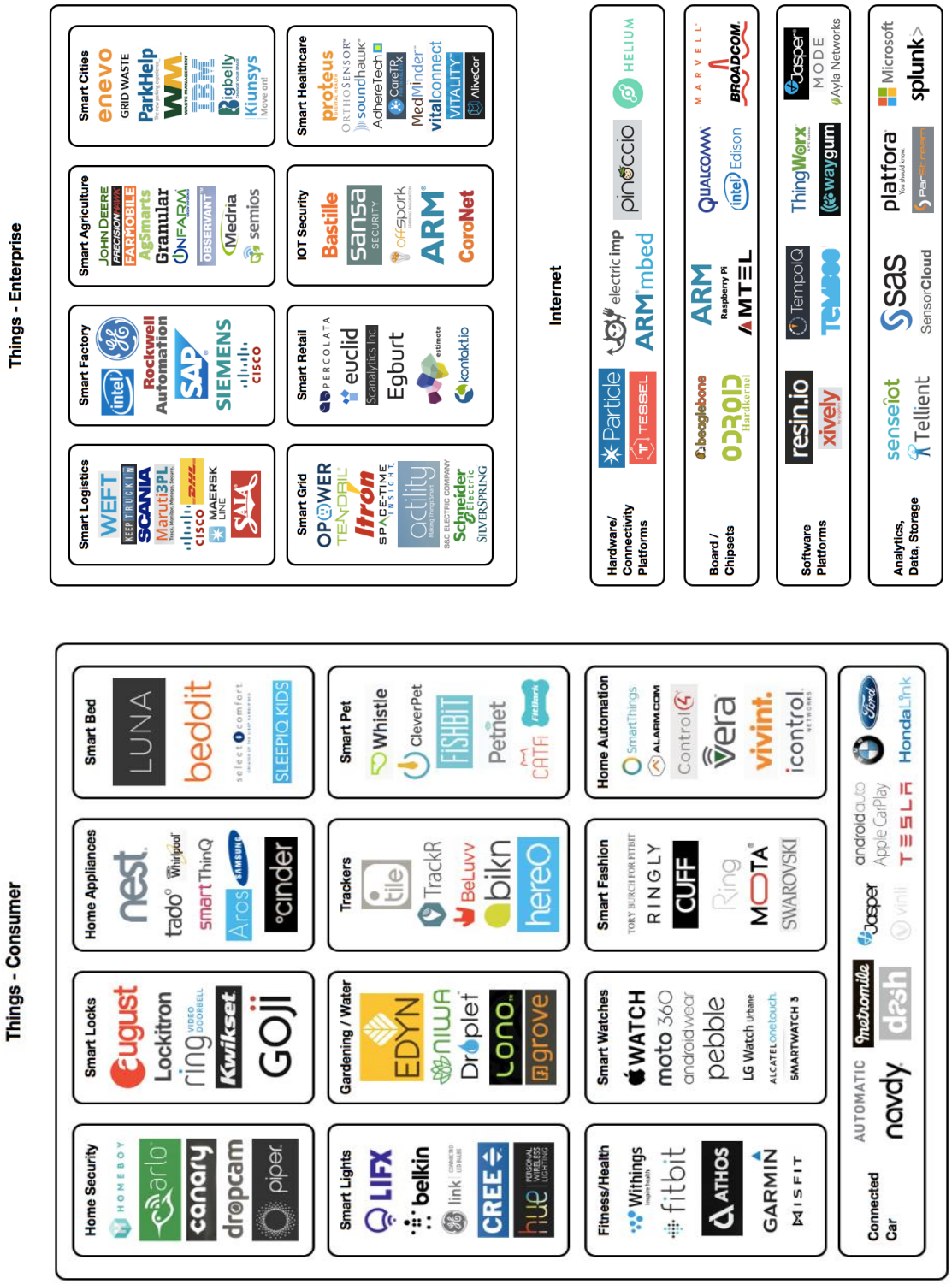
Appendix V: From Industry 1.0 to Industry 4.0

Source: Siemens



Appendix VI: Mapping the Internet of Things market

Source: Chris McCann. Community Lead at Greylock Partners



Appendix VII: Declaration of authorship

Declaration of authorship

I hereby declare that I have written this thesis without any help from others and with-out the use of documents and aids other than those stated above.

Furthermore, I have mentioned all used sources and have cited them correctly according to the citation rules defined by the Chair of Entrepreneurship and Technology Transfer

Moreover, I confirm that the paper at hand was not submitted in this or similar form at another examination office, nor has it been published before.

With my signature I explicitly approve that HHL will use an internet-based plagiarism detector which screens electronic text files and looks for similar pieces on open-access websites as well as similarities in work previously submitted.

Place, date

Berlin, 15.7.2015

(Signature)

8 Publication bibliography

acatech (2013): Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group. Available online at http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf, checked on 04-Feb-15.

Amit, Raphael; Zott, Christoph (2012): Creating value through business model innovation. In *MIT Sloan Management Review* 53 (3), checked on 17-Jan-15.

Baxter, Pamela; Jack, Susan (2008): Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. In *The Qualitative Report* 13 (4). Available online at http://www.nova.edu/ssss/QR/QR13-4/baxter.pdf, checked on 08-Mar-15.

Bosch (2014): IoT Strategy Whitepaper, checked on 20-Jan-15.

Chaouchi, Hakima (2010): The Internet of things. Connecting objects to the web. London, Hoboken, NJ: ISTE; John Wiley & Sons.

Chesbrough, Henry (2007): Business model innovation: it's not just about technology anymore. In *Strategy & Leadership* 35 (6), pp. 12–17. DOI: 10.1108/10878570710833714.

Chesbrough, Henry (2010): Business Model Innovation: Opportunities and Barriers. In *Long Range Planning* 43 (2-3), pp. 354–363. DOI: 10.1016/j.lrp.2009.07.010.

Chui, Michael; Löffler, Markus; Roberts, Roger (2010): The Internet of Things. McKinsey Quarterly 2010 Number 2 (2), checked on 19-Jan-15.

DaCosta, Francis (2013): Rethinking the Internet of Things. A scalable approach to connecting everything. [New York, N.Y.]: ApressOpen (The expert's voice in Internet technologies).

Danneels, Erwin (2004): Disruptive Technology Reconsidered: A Critique and Research Agenda. In *Product Innovation Management* 21, checked on 21-Jan-15.

Eisenhardt, Kathleen M. (1989): Building Theories from Case Study Research. In *The Academy of Management Review* 4, pp. 532–550. Available online at http://www.jstor.org/stable/258557, checked on 06-Mar-15.

Firestone, William A. (1993): Alternative Arguments for Generalizing From Data as Applied to Qualitative Research. In *Educational Researcher* 22. Available online at http://edr.sagepub.com/cgi/content/abstract/22/4/16, checked on 08-Mar-15.

Fleisch, Elgar; Weinberger, Markus; Wortmann, Felix (2014): Business Models and the Internet of Things, checked on 18-Jan-15.

General Electric (2012): Industrial Internet, checked on 21-Jan-15.

General Electric (2014): State of the Industrial Internet - GE Minds + Machines 2014. Keynote speech. Available online at https://www.youtube.com/watch?v=UUw4SfXzMrw.

Gertner, Jon (2014): Behind GE's Vision For The Industrial Internet Of Things. Available online at http://www.fastcompany.com/3031272/can-jeff-immelt-really-make-the-world-1-better, checked on 19-Jan-15.

Giesen, Edward; Riddleberger, Eric; Christner, Richard; Bell, Ragna (2010): When and how to innovate your business model. In *Strategy & Leadership* 38 (4), pp. 17–26. DOI: 10.1108/10878571011059700.

Gubbi, Jayavardhana; Buyya, Rajkumar; Marusic, Slaven; Palaniswami, Marimuthu (2013): Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions. In *Future Generation Computer Systems* 29 (7), checked on 02-Feb-15.

Hui, Gordon (2014): How the Internet of Things Changes Business Models. Harvard Business Review. Available online at https://hbr.org/2014/07/how-the-internet-of-things-changes-business-models.

Johnson, Mark W.; Christensen, Christensen M.; Kagermann, Henning (2008): Reinventing your business model, checked on 22-Jan-15.

Kyriazis; Varvarigou (2013): Smart, Autonomous and Reliable Internet of Things. In *Procedia Computer Science* 21, pp. 442–448.

Lindgardt, Zhenya; Reeves, Martin; Stalk, George; Deimler, Michael S. (2009): Business Model Innovation: When the Game Gets Tough, Change the Game. In *Boston Consulting Group,* checked on 17-Jan-15.

Porter, Michael E. (1998): Competitive Advantage. New York, London: Free Press.

Porter, Michael E.; Heppelmann, James E. (2014): How Smart, Connected Products Are Transforming Competition. Harvard Business Review.

Teece, David J. (2010): Business Models, Business Strategy and Innovation. In *Long Range Planning* 43, pp. 172–194, checked on 18-Jan-15.

Uckelmann, Dieter; Harrison, Mark; Michahelles, Florian (2011): Architecting the internet of things. Berlin, Heidelberg, New York: Springer.

Velamuri, Vivek K.; Bansemir, Bastian; Neyer, Anne-Katrin; Moslin, Kathrin M. (2013): Product service systems as a driver for business model innovation. In *Applied Social Research Methods Series* 17 (01). DOI: 10.1142/S1363919613400045.

Vermesan, Ovidiu; Friess, Peter (2013): Internet of things. Converging technologies for smart environments and integrated ecosystems: River Publishers (River Publishers Series in Communications).

Yin, Robert K. (1984): Case Study Research. In *Applied Social Research Methods Series* 5 (2).

Zott, Christoph; Amit, Raphael; Massa, Lorenzo (2011): The Business Model: Recent Developments and Future Research. In *Journal of Management* 37 (4), pp. 1019–1042. DOI: 10.1177/0149206311406265.