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Service Logic in Digitalized Product Platforms

A Study of Digital Service Innovation in the Vehicle Industry

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DOCTORAL DISSERTATION

Abstract

The digitalization of products has become an important driver for service innovation in manufacturing firms. The embedding of digital technology in previously non-digital products creates digitalized product platforms that enable digital service innovation. Digital service innovation offers new business opportunities for manufacturing industries, as well as challenges established premises for value creation. While digital service innovation can be found in many manufacturing industries, this thesis studies service logic in digitalized product platforms in the vehicle industry.

Existing Information Systems (IS) literature presents challenges in digital service innovation relating to value, architecture, and generativity. The design of the architecture of digitalized product platforms requires the identification and combination of digital and non-digital assets. Understanding the architectural aspects is useful in digital service innovation. Moreover, with growing instances of generative digital technologies, it is challenging to develop strategies to leverage generativity for service design in digitalized product platforms. While digital technologies are embedded in products, the role of technology-embeddedness in value creation of digital services is relatively unexplored. Drawing on these challenges, this thesis describes and conceptualizes the underlying premises brought by the architecture and generativity to the value creation of services in digitalized product platforms. The research question addressed in this thesis is: *What are the underlying premises for services in digitalized product platforms*?

To address the question, an interpretive qualitative research approach was adopted in a collaborative research project concerning services enabled by digitalization of vehicles. Drawing on digital innovation and service literature, this thesis presents a theoretical perspective on the role of the architecture and generativity of digitalized product platforms for value creation of digital services. This perspective is conceptualized as underlying premises for this specific class of services. The premises frame the service logic in digitalized product platforms and provide a ground for understanding services in digitalized product platforms in relation to value dimensions, architecture and generativity. The premises are based on five concepts: value-in-architecture, value-in-connectivity, fundamental asset for value creation, mutual dependence of modular and layered modular assets, and re-evaluation of value propositions. The proposed premises offer a basis for understanding value creation of this class of services, and guidance for manufacturing firms designing digitalized product platforms.

Keywords: digital services, premises, digital service innovation, digitalized product platforms, service logic

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For some reason many parents think their kids are special, even if they are not. My parents are not different. It is a nice feeling to provide evidence to their claim as their son has completed his doctoral studies. My biggest inspiration for pursuing doctoral studies was my parents. Without their continuous moral support their son would not achieve anything special.

If somebody asks me questions like 'why did you pursue a PhD', 'who told you to do this', 'why didn't you do something else', I honestly have no clear answer. I simply considered a PhD as a continuation of studies after masters, so I applied for the doctoral position. I am grateful to Maria Åkesson for selecting me for the position.

I do not think that you have to be an extremely talented person to pursue doctoral studies; but you need a great supervisor like Maria Åkesson. She has been very patient during the last five years. To deal with a student like me, there ought to be a supervisor like her. There are basically two types of PhD students: one being similar to extremely sharp shooters; give them a gun and they will shoot the target accurately. They do not need much coaching. Another type comprises of not-so-sharp shooters. They can also shoot well...but only after getting proper coaching. I was undoubtedly in the second group and Maria was a great coach who gave me support whenever I needed it. She made sure that I could shoot my target. I really hope that next time around she gets a sharp-shooter.

I would like to thank Michel Thomsen for being a perfectionist when reading my texts. The experience was sometimes really tough, but I realized this is what a good reviewer has to do. To have a super skeptical reviewer-like co-supervisor was a blessing for me. My other co-supervisor, Magnus Bergquist, was also very helpful. I learnt a lot from him during our meetings and paper writing sessions. I would also like to thank University of Gothenburg's Jan Ljungberg for his valuable feedback on my research. And a special thanks must go to Ojelanki Ngyenyama for his lectures on philosophy of science.

I got married when I was half way into my doctoral studies. I heard the same question quite a few times, 'Should someone get married during his/her PhD?' My answer would be, 'yes, everybody should get married during his/her doctoral studies but he/she really needs to find a loving person'. I found not only a loving, but a caring and supportive person in my wife. She had to commute every day for her classes at Lund University and still managed to be there for me. I am really grateful to you my dear. Things would have been much harder without you.

I must thank God for keeping me fit almost all the time during my PhD studies. I suffered from a cold a few times, but I think it should not be treated as illness in Sweden. I truly believe that a person needs divine support to remain safe and sound, especially when he/she is living thousands of miles away from his/her homeland. Many nice things happened to me unexpectedly and I would like to thank God for all of them.

The colleagues of Halmstad University's MI-lab were also a great driving force for me. Whenever I felt bored at the office, the next thing that came to my mind was, 'let me see what Lars-Olof is doing and make him bored too'. My suggestion to the future MI-lab PhD students is, 'Whenever you need to talk, go to Lars-Olof's office. He will talk'. I would like to thank Asif Akram with whom I took part in the same research project. We were like brothers. Whenever I needed help, he was always there. A special thanks to Torben Svane for giving me opportunities to teach. I am really thankful to Jesper Lund for making my life easier by informing me of all the practical stuffs regarding printing this thesis. Everybody else at MI-lab was awesome. I felt like a part of a great family with amazing family members. I would like to thank Esbjörn, Susanne, Ewa, Christer, Carina, Jesper Hakeröd, Phillip, Caroline, Karl, Pontus, Janne, Micke, Pär, Ylva, and Chatarina. Thanks to Meghan for proofreading my texts. I would like to thank Eva Nestius, the former research administrator at the School of IT, for dealing with my issues with visas and residence permits. Special thanks to the administrative staff, Stefan Gunnarsson, Jessika Rosenberg, and Ulla Johansson for helping me order books and organizing all my travels for conferences and seminars.

Soumitra Chowdhury

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1. Introduction

The digitalization of products such as vehicles, home appliances and medical equipment is undoubtedly a common phenomenon today. This digitalization of products expands the use of digital technology in our society and influences our day-to-day lives (Nambisan 2013). Digitalization is the socio-technical process of embedding digital technology into physical products and creating new values relating to the use of these products (Tilson et al. 2010; Yoo 2013).

To leverage value from digitalization, manufacturing firms are developing digitalized product platforms that open up opportunities for service innovation (Gawer 2014; Lusch and Nambisan 2015; Yoo et al. 2010a). Digital service innovation refers to the combination of digital technology and physical products to design new digital services (Barrett et al. 2015; Yoo et al. 2010a). A digitalized product platform is referred to as a set of digital and non-digital assets that enable the design of digitalized products and digital services (Meyer and Lehnerd 1997, Robertson and Ulrich 1998; Yoo et al 2010a). For example, in the vehicle industry, the embedding of digital technology enables wireless communication services and remote vehicle diagnostics in platforms (Henfridsson and Lindgren 2005; Kuschel and Dahlbom 2007). In the vehicle industry, there are substantial research and development initiatives to envision the benefits of digitalization of vehicles, such as digital services for predicting faults, improved up-time in public transport, real-time vehicle monitoring of driverless vehicles, improved traffic planning, better maintenance and increased traffic safety (see e.g. VINNOVA 2012; EUCAR 2012).

To leverage the values of digitalization there are however profound challenges for manufacturing firms. While manufacturing firms follow product innovation logic, digitalization requires them to simultaneously manage service innovation logic (Hylving et al. 2012; Tripsas 2009). This thesis stems from this discussion and specifically inquires into digital service innovation in digitalized product platforms. The digitalization of products can exhibit specific architectural and value aspects that can have profound implications for the design of digital services (Yoo et al. 2010a). The characteristics of digital technology make digitalized product platforms generative (Yoo 2013). During a product´s lifecycle, new services and functionality can be added to the platform and existing services can be re-designed and customized. This generativity in digitalized product platforms stimulates radically new business models, as well as digital service innovation (Tilson et al. 2010). While the architecture and generativity of digitalized product platforms offer opportunities for manufacturing firms, they are also sources of challenges for the traditional business logic of manufacturing firms bringing with it increased complexity of contemporary products (Lee and Berente 2012; Yoo 2013). The previously stable structure in manufacturing industries has become de-stabilized, and the transaction oriented business has got driven towards service orientation (Alter 2012).

The challenges following the digitalization of products have been observed in different industries, such as the camera manufacturing industry. Kodak, for example, was challenged by the digitalization of cameras. Kodak continued to sell film cameras while underestimating digital imaging services and the firm faced market share loss, stock price drop, and rapid workforce decline (Lucas and Goh 2009). The digitalization of the camera profoundly challenged the business logic that the camera manufacturing industry built up for decades (Tripsas 2009). The challenges of digitalization have also been witnessed in the vehicle industry. Vehicle manufacturing firms that previously only focused on vehicle sales are forced to assimilate digital service innovation into their future strategies (Kushel 2009; Jonsson et al. 2008). When assimilating digital service innovation, firms are required to add new knowledge of digital service innovation to their existing knowledge base (Lee and Berente 2012). Manufacturing firms are thus required to change their existing ways of value creation in digital service innovation (Lusch and Nambisan 2015). The *architecture* and *generativity* of digitalized product platforms play significant roles in these changes and in value creation of digital services (Tilson et al. 2010; Yoo 2013).

The first challenge to manufacturing firms, is designing the platform *architecture* with all of the required assets to leverage digital service innovation. The core of this challenge is that digitalized product platforms and assets were not previously required for non-digital products or services (Yoo 2010). In digitalized product platforms, service value is created through the use of the product and in this respect not separable from the underlying digitalized product platforms (Barrett et al. 2015). Manufacturing firms are required to strategize for the architecture and platform assets for digital service innovation. Inquiring about the role of architecture for digital service innovation in digitalized product platforms can provide useful knowledge to understanding the relationship between the product and service value.

Second, it is challenging for manufacturing firms to deal with the *generativity* in digitalized product platforms (Tilson et al. 2010; Yoo 2013). On the one hand, generativity affords flexibility and growth in both scale and scope of the platform, for example new combinations of services can be designed continuously in collaboration with customers. Collaboration between different stakeholders is a driver to leverage value of digitally enabled generativity (Yoo et al. 2010a). On the other hand, there is a tension between the flexibility afforded by generativity and the constraints imposed by prior investments and design decisions (Tilson et al. 2010). The generativity in digitalized product platforms thus challenges manufacturing firms to balance flexibility and stability. By examining the role of generativity in customer relationships and value creation, research can provide useful knowledge for digital service innovation (Yoo 2013).

Early Information Systems (IS) literature describes value from a firm perspective, i.e., value of digital technology or digital services for firms (Bharadwaj, 2000; Jarvenpaa and Leidner 1998). Regarding digitalization of products with embedded technology, past research shows both firm-centric and customer-centric value creation in relation to digital services (Jonsson et al. 2008). Although there is significant research on value creation in digital services, the role of technology-embeddedness in value creation is not widely researched (Nambisan 2013; Kohli and Grover 2008). Digitalization enables a significant increase in the quantity of data and introduces a need to inquire into the role of information as the source of value creation in digitalization (Bharadwaj et al. 2013). To understand technology-embeddedness and the role of information, a conceptualization of the specific premises for services in digitalized product platforms is important. Value dimensions are context specific and the underlying premises for services in digitalized product platforms depend on a specific context where platform architecture and generativity play a significant role in value creation (Lusch and Nambisan 2015).

IS literature provides a body of knowledge on the architecture and generativity afforded by digital technology. The IS literature on architecture focuses on the layered architecture of digital technology and the layered modular architecture (see e.g. Gao and Iyer 2006; Lusch and Nambisan 2015; Yoo et al. 2010a) and indicates that the layered architecture of digital technology plays an important role in digitalized product platforms. Digitalized product platforms consist of modular architecture of physical products and layered architecture of digital technology (Yoo et al. 2010a). The combination of modular and layered architecture gives rise to the layered modular architecture, which opens up opportunities for digital service innovation (Lusch and Nambisan 2015; Yoo et al. 2010a). Research has shown that architecture plays a significant role in innovation as the properties within the architectural layers of digital technology can facilitate innovation (Henfridsson et al. 2014). Although opportunities are arising from this architecture, less knowledge is developed regarding the architecture and assets in digitalized product platforms. IS scholars have been encouraged to put an emphasis on empirically investigating architectural aspects and its impact on digital service innovation (Lusch and Nambisan 2015; Yoo et al. 2010a; Yoo 2013).

The IS literature on generativity (see e.g. Eaton et al. 2015; Henfridsson and Bygstad 2013; Tilson et al. 2010; Yoo 2013) focuses on the paradoxical nature of generativity. Manufacturing firms can exert control over generativity during the design of digital services to maintain ownership of the digital platforms as well as in control over the platforms (Tilson et al. 2010). The literature provides knowledge of the enabling aspects of generativity, but less is known about the role of generativity for services in digitalized product platforms. Research agenda has been put forward in IS to investigate generativity and digital assets (see e.g. Kallinikos et al. 2013; Lusch and Nambisan 2015; Yoo et al. 2010a).

Against this background, this thesis describes and conceptualizes the underlying premises brought by the architecture and generativity to the value creation of services in digitalized product platforms. The overall research question is:

What are the underlying premises for services in digitalized product platforms?

The aim of this thesis is to contribute an understanding of value and service perspectives of the digitalization of products to IS literature. Based on digital innovation literature, the concepts that guide my research include those of layered architecture of digital technology and layered modularity (see e.g. Lusch and Nambisan 2015; Yoo et al. 2010a). To investigate the capacity of platform assets and customer involvement, the concept of generativity is used (see e.g. Tilson et al. 2010; Zittrain 2006; Yoo 2013). To conceptualize services in digitalized product platforms, this thesis applies the perspective of service dominant logic (see e.g. Lusch and Nambisan 2015; Vargo and Lusch 2004; Vargo et al. 2008). To explain the transaction oriented business of manufacturing firms, this thesis also incorporates the views of goods logic (see e.g. Vargo and Lusch 2008). These two views are useful to highlight the challenges that manufacturing firms face in digital service innovation. This thesis contributes by conceptualizing services in digitalized product platforms with the premises concerning value dimensions, architecture and generativity. These premises frame the service logic in digitalized product platforms.

To address the research question, I adopted an interpretive qualitative research approach. I took part in a collaborative research project with a vehicle manufacturing firm SmartBus (a pseudonym). The project goal was to develop Remote Diagnostics Technology and design Remote Diagnostics Services (RDS). The research project took place within the period from 2010-2013.

This thesis is a collection of five individual papers and a cover paper. The cover paper is structured as follows. Section two presents the research context of the thesis. Section three presents the literature review that provides guidance to this research. Thereafter, research methodology is presented in section four. Section five outlines the contributions from the individual papers and presents the premises for services in digitalized product platforms. This section also presents theoretical implications. The cover paper concludes with a discussion regarding the practical implications and future research possibilities. In this thesis, the five papers are referred to as follows:

Paper 1: Chowdhury, S. and Åkesson, M. (2011). "A Proposed Conceptual Framework for Identifying the Logic of Digital Services", in the Proceedings of the 15th *Pacific Asia Conference on Information Systems* (PACIS), Brisbane, Australia

Paper 2: Chowdhury, S. and Akram, A. (2013). "Challenges and Opportunities Related to Remote Diagnostics: An IT-Based Resource Perspective", *International Journal of Information Communication Technologies and Human Development* (IJICTHD), Vol 5, No. 3. pp. 80-95

Paper 3: Chowdhury, S., Bergquist, M. and Åkesson, M. (2014). "Architectural Characteristics of the Digital Services Enabled by Embedded Technology: A Study on the Remote Diagnostics Services", in the Proceedings of the *47th Hawaii International Conference on System Sciences* (HICSS), USA

Paper 4: Chowdhury, S. (2014) "Expanding business from products to digital services: value dimensions of digital services enabled by embedded technology", in the Proceedings of the *8th Mediterranean Conference on Information Systems (MCIS)*, Verona, Italy

Paper 5: Chowdhury, S., Åkesson, M., and Thomsen, M. "The Implications of Generativity for Service Innovation in Digitalized Product Platforms", Submitted to an international journal

2. Research Context – Digital Service Innovation in the Vehicle Industry

The digitalization of vehicles is being carried out in a rapid pace in recent time. Moving beyond a simple embedded radio, rapid digitalization of vehicles opened the way for digital service innovation (Henfridsson et al. 2014). To sustain in the business, vehicle manufacturing firms are transforming regular vehicles into enabling platforms to provide digital services to customers, for example, transport operating companies in cities. The firms' businesses have traditionally been focusing on vehicle sales. The expansion of business towards digital services is a new venture. In this respect, digital service innovation is a challenge for the vehicle manufacturing firms. Examples of digital service innovation in the vehicle industry include infotainment services (Henfridsson and Lindgren 2005), commercial vehicle drivers' working time monitoring services (Andersson and Lindgren 2005), and navigation and rear-seat entertainment services (Henfridsson et al. 2014). Besides these services, remote diagnostics services are examples of the digitalization of vehicles that are having an impact on the business of vehicle manufacturing firms and their customers (Kuschel and Dahlbom 2007; Slywotzki and Wise 2003). The industry context has gained importance in IS research and there is an urge for research within industry context (Chiasson and Davidson 2005). This emphasis motivates to carry out the research on digital service innovation in the vehicle industry. The following scenario attempts to clarify the practical and societal motivation for studying digital service innovation in the vehicle industry.

When a person travels by bus, the main concern is arriving to the destination on time, not how the bus functions or current conditions of the bus, i.e., whether or not all the parts of the engine are working properly. Even if these things are thought about less, the condition of the vehicle is influencing the whole journey. A malfunction of the engine or the brakes can cause serious accidents. Even a problem with a less vital part of the vehicle, such as the doors, can hamper your journey, forcing the driver to stop the bus to access and possibly fix the problem. Not only do the passengers get delayed, but the operating company that runs the bus will also be affected, requiring unscheduled repair and maintenance. The firm that manufactured the bus might have to conduct this repair and maintenance if there is a mutual agreement between the firm and the transport company. Any unscheduled repair and maintenance requires extra time and cost, to either the manufacturing firm or the transport company. Effective, efficient and safe transportation can benefit the transportation business as well as our society in means of saving all parties the extra hassle, time and cost of unscheduled maintenance.

The importance of effectiveness, efficiency and safety has been recognized by governmental and non-governmental authorities in different parts of the world. The authorities have made significant investments in research focused on the remote diagnostics of vehicles. Most of these research activities are carried out in collaborations with vehicle manufacturing firms. An example of such was a 16 million Euro project, in which the European Council for Automotive R&D (EUCAR) collaborated with German automotive manufacturers Mercedes, MAN, and Swedish manufacturer Scania (EUCAR 2012) with the aim to develop remote diagnostics for predictive maintenance.

Remote diagnostics is driven by numerous digital sensors that are embedded in modern vehicles. Sensors are interconnected and run by software operated Electronic Control Units

(ECUs). The main task of this computer controlled sensor network is to continuously adjust vehicle operations (Kuschel 2009). The sensors work constantly to collect, store and analyze data concerning the state of the machinery parts and assist in determining when maintenance is needed (Biehl et al. 2004; Jonsson 2010). Remote diagnostics is organized around rich forms of digital data gathering that allows for extensive, real-time, model-based computations (Simmons, 2001). Any deviations are recognized by the ECUs and are logged as error codes. These codes can be valuable feedback for drivers and most importantly to transport operating companies and their maintenance technicians for the repair work. Changes may be made to the ECU software making it possible for driver behavior and fuel consumption can be tracked (Kuschel 2009).

Remote diagnostics is also an alternative to preventive and corrective maintenance of vehicles. Preventive maintenance refers to performing maintenance activities on a regular basis even when no problems in vehicles exist. This is done to prevent any possible future anomalies. On the other hand, corrective maintenance means that a vehicle is repaired after a fault occurs (Wang 2002). Both of these maintenance strategies have been used in the vehicle industry for many years. Preventive maintenance is not cost effective as vehicle parts are changed even if it is not required, as the replacement of parts is based on a timeframe instead of the actual condition of the vehicle. Moreover, this method costs customers extra money. Corrective maintenance leads to vehicles being out of service for an unspecified period while the repair work is being carried out, which is not convenient for customers (Bouvard et al. 2011). According to a report published by the Commission of the European Community, repair and maintenance fees accounts for 40% of the total lifetime cost of vehicle ownership (You et al. 2005). Thus, the affordability of vehicles depends not only on the initial vehicle cost but the cost of repair and maintenance.

On the contrary to preventive or corrective maintenance, remote diagnostics is based on predictive maintenance. Remote diagnostics can examine automotive fault codes and sensor values while vehicles are running on the road without the involvement of a vehicle service technician. These readings are wirelessly transmitted to a remote server, where vehicle information, such as records of vehicle service and previous repair, are stored. These records assist in predicting faults before they happen. If a problem is predicted, the drivers can be warned of the malfunction, get help from an advisor to assess the severity of problem and schedule maintenance or repair. If needed, advanced diagnostic algorithms could be remotely downloaded to the vehicle to perform complex diagnostic tasks, such as activating recovery and rescue services to deal with faulty conditions and, possibly, save lives. Remote diagnostics can aid in the increase of safety by, for example, early detection of low tire pressure, determining when an oil change is needed, or indicating when brake linings are in need of replacement (Bouvard et al. 2011; You et al. 2005). Early warnings of problems may prevent some on-the-road breakdowns and, in some cases, may prevent accidents. Remote diagnostics is generally regarded as one of the most important vehicle services.

This thesis reports from a project led by a vehicle manufacturing firm, SmartBus (a pseudonym), while developing remote diagnostics technology and designing remote diagnostics services (RDS). Although the early stage of development for the technology was straightforward, meeting customer needs and the business behind RDS was found to be unclear to SmartBus.

3. Related Literature

This section describes the concepts used in this thesis and their relevance to study services in digitalized product platforms. The description of digital service innovation presents the overall area of this research. Later, different classes of digital services are presented to distinguish services in digitalized product platforms from other digital services. Then, service logic perspective of value is presented to study value creation in digitalized product platforms. Thereafter, architecture of digitalized product platforms is presented which is followed by a review of the generativity concept. The section ends with presenting research challenges in digital service innovation relating to value dimensions, architecture, and generativity.

3.1 Digital Service Innovation

The term ‘Digital Service Innovation’ denotes service innovation in the digital age (Barrett et al. 2015), and emphasizes the use of digital technology in different contexts. Unlike the static use of computers in homes and offices, digital technologies are now pervasive in nature and situated everywhere and sometimes embedded with everyday objects. With the advent of different digital technologies, the approach in service innovation research has also changed over the years. Different approaches can be found in service innovation research, such as the assimilation approach, the technologist approach, the demarcation approach and the synthesis approach (Droege et al. 2009; Miles 2012).

Research taking an *assimilation approach* in service innovation has similarities with product innovation research. Product innovation follows ‘product life cycle’ where the first phase in the cycle is the use of a new technology to produce new products. The second phase deals with improving the quality of products by adding new features and the final phase focuses on product standardization and cost reduction (Utterback and Abernathy 1975). In line with product innovation, the assimilation approach for service innovation research, services are considered as outputs to create differentiation in the offerings of firms (Coombs and Miles 2000; Droege et al. 2009). Research within this approach advocates that product innovation contexts can easily be transferred to service innovation research. Hence, concepts such as standardization and delivery are applied while customer involvement is often disregarded in this approach (Drejer 2004; Droege et al. 2009). The literature with this approach views service innovation primarily as market driven where firms create new offerings (Barrett et al. 2015; Sirilli and Evangelista 1998).

Other approaches in service innovation research do not view service innovation similar to product innovation. The *technologist approach* is influenced by ‘reverse product cycle’ proposed by Barras (1986), and emphasizes on different patterns of innovation in services. The cycle portrays the beginning of service innovation with the adoption of information technology to increase the deliverance efficiency of existing services. Later in the cycle, technology is applied to improve the quality and effectiveness of the services. In the final phase of the cycle, the technology assists in generating wholly transformed or new services (Barras 1986; Barrett et al. 2015). Examples of this approach can be linked to the research on Internet computing in service innovation (Carlo et al. 2011; Lyytinen and Rose 2003).

The *demarcation approach* can be explained using four dimensions of service innovation: service concept, client interface, service delivery system and technological options (den Hertog 2000). Unlike the technologist approach that emphasizes initiating service innovation with a technology adoption, the demarcation approach considers characterizing new services, client interfaces, and delivery systems where technology can work as facilitator or enabler.

Finally, as the term suggests, the *synthesis approach* in service innovation argues for bringing together the knowledge of product innovation and service innovation (Droege et al. 2009). This is particularly important when looking at the growth of intertwinement between products and services (Drejer 2004). The embedding of digital technology in physical products for digital service innovation is an example of intertwining products and services. Following Lusch and Nambisan (2015) and Yoo et al. (2010a), digital service innovation is referred to as the carrying out of combinations of digital and physical components to create new digital services. Digital service innovation can be linked to the synthesis approach as the knowledge of product innovation and service innovation will be useful.

Product innovation research is often related to *modular product architecture* (see e.g. Ulrich 1995; Utterback and Abernathy 1975) and digital products and services are linked with the layered architecture of digital technology (see e.g. Adomavicious et al. 2008; Yoo et al. 2010a). The modular product architecture is composed of product specific connected components, loose coupling between components through specific interfaces, and a single design hierarchy (Ulrich 1995; Yoo et al. 2010a). Examples of modular product architectures include modern vehicles where vehicle specific parts such as engines, electrical systems, brakes are connected through specific interfaces and loose coupling allows easy replacement of any specific part (Ulrich 1995).

The layered architecture of digital technology consists of four layers: device layer, network layer, application functionality layer and contents layer (Benkler 2006; Yoo et al, 2010a). The device layer consists of the hardware and operating system; the network layer deals with connectivity (both wired and wireless); the application functionality layer is made up of applications that directly serve users to create, manipulate, and store contents and the contents layer includes contents such as texts, sounds images, etc. (Yoo et al. 2010a). When digital technology is embedded with product modules, the layers of digital technology get intertwined with the product. As a result, the embedded digital technology facilitates digital functionalities and enables digital service innovation. With the embedded digital technologies in modular products, the modules of products can be used for computations and information processing that enables new digital services. For example, embedded digital technology such as active ignition sensing technology in vehicles has enabled the monitoring of breaking and shifting behavior (Andersson et al. 2008). Remote monitoring and diagnosing of vehicles or industrial equipment are other examples of innovative digital services enabled by embedded digital technology in vehicles (Jonsson et al. 2008; Jonsson et al. 2009).

3.2 Classes of Digital Services

Digital services can be defined as the application of a firm's resources to provide digitally enabled solutions to customers' needs (Lyytinen and Yoo 2002). Generally, digital services are exemplified with e-business services that are provided over the Internet (Williams et al. 2008). E-business services are concerned with using the Internet to make transactions (buying and selling), social networking, audio or video sharing, information searching, etc. With the growing number of new digital technologies, digital services are no longer limited to these services. Various new forms of digital services have emanated over the years as smartphones and digitalized products have become enabling media for digital services (Yoo 2010). Three classes of digital services can be identified in the literature based on their relationship to products and devices. Here, the term product refers to the objects that possess physical shape, size and tangibility. The classes of services are *'device independent services'*, '*digital platform dependent services*', and *'specific product dependent services*' (see Figure 1).

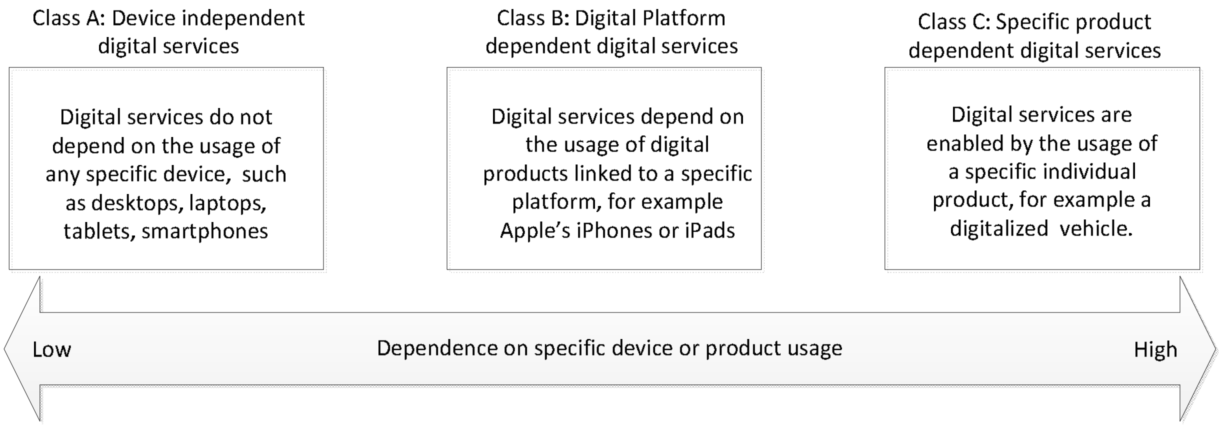

Figure 1: Three Classes of Digital Services

The dependence of using a specific digital or digitalized product varies for different classes of digital services (Figure 1). Many digital services are designed without being linked to the usage of a particular digital product. This means that customers can receive digital services independent of a specific device, i.e., the services can be received with different digital devices. I note these services as *'device independent services'* (Class A in Figure 1). The architecture of services in Class A is made up of loosely coupled components, which have relative independence during usage (Ulrich 1995; Yoo et al. 2010a). For example, the use of VOIP software is loosely coupled from any digital hardware. Hence, VOIP services can be received using desktop, laptop, smartphones or tablet computers (Yoo et al. 2010b). Similar to VOIP services, digital services in Class A are loosely coupled with digital products, i.e., the services are not attached to a particular digital product. Using desktops, laptops, smartphones, tablets connected to the Internet, most of the e-business services can be used (Amit and Zott 2001; Scupola 2011; Williams et al. 2010). For example, buying a book from Amazon.com can be done on either a PC, smartphone or tablet, as long as there is an internet connection.

The second class of digital services (Class B in figure 1), are digital services designed for a specific platform. I term these services '*digital platform dependent digital services*'. Unlike 'device independent services' that can be accessed using different digital products, these services are only accessible within a digital platform. The coupling between components is not as loose as Class A services, as customers need to use a product from a particular digital platform. For example, many digital services provided by Apple are highly dependent on the usage of the products manufactured by Apple (Eaton et al. 2015; Ghazawneh and Henfridsson 2013; Tilson et al. 2012). Thus, to access many of the digital services provided on the Apple platform, one must use a digital product from Apple's platform, such as an iPhone or iPads. Another example is the Amazon Kindle that is dedicated for content services offered by Amazon. Therefore, on the contrary to 'device independent services', there is a dependence on the usage of a particular product platform for the 'digital platform dependent services'.

The third class of digital services '*specific product dependent services*' (Class C in Figure 1), are services with high dependence on a specific digitalized product. These services are specifically linked to the usage of a particular individual product. Hence, the 'specific product dependent digital services' are tightly coupled to the product component in the digitalized product platform. For example, when manufacturing firms design remote monitoring service for construction equipment (e.g. a crane), the function of each individual crane is monitored during its usage (Jonsson et al. 2008). The monitoring information service provided is of value only related to that specific crane. The information needed to provide the service is generated from the usage of that crane. The products in Class C can have non-digital features and digitalization enables digital features to them. The modules of the products are embedded with digital devices and capable of performing digital functions. The embedded digital devices can be re-programmed and new functions can be performed using the devices. Due to re-programmability, new digital services can be designed during the life-cycle of a digitalized product (Kallinikos et al. 2013). Each digitalized product is hence used as an enabling medium for designing and providing digital services, whether it is vehicle, construction equipment or an elevator (Jelassi 1993; Jonsson et al. 2008; Henfridsson and Lindgren 2005).

Services in digitalized product platforms belong to Class C services. In this age of digitalization, services enabled by digitalization play a significant role in manufacturing firms for their endeavor in new value creation (Jonsson et al. 2008; Nambisan 2013; Svahn et al. 2009; Yoo et al. 2010a). Research on this specific class of services can be valuable for understanding their implications for innovation.

3.3 Value Creation: Service Logic Perspective

Digitalization is creating opportunities for new value creation and therefore it is important to re-conceptualize value from traditional thinking (Lusch and Nambisan 2015). Two perspectives of value creation can be identified from the literature: goods logic perspective and service logic perspective. Traditionally, value is understood with the notion of value-in-exchange which represents goods logic perspective and refers to transactional value. Value-in-exchange suggests that value is created by selling products or services (Alter 2010; Vargo and Lusch 2008).The dominant focus on the exchange of products or services can be explained using the marketing mix concept (Borden 1964; Perreault and McCarthy 2002). The marketing mix concept is well known as the four Ps of marketing. The four Ps of marketing are: product, price, promotion and place (Perreault and McCarthy 2002). First, firms develop products to sell. Later, firms set prices for the products. They then promote the products to customers. Lastly, they reach out the customers' place using channels, inventory and transportation (Kotler and Keller 2006; Perreault and McCarthy 2002). The marketing mix represents a firm's point of view and does not portray a customer's point of view (Bardhan et al. 2010). The concept is criticized for not focusing on relation building with customers, and for focusing on tangible monetary value, thus overlooking intangible value such as better customer relationships (Kohli and Grover 2008). Relationship building with customers emphasizes on understanding customers' needs and on customer perceived value (Grönroos 1996).

With an emphasis on customer relationship oriented business, the concept of value-in-use emerged (Grönroos 2006; Vargo and Lusch 2004). Value-in-use suggests that value is co-created by customers rather than produced and distributed by the firm (Vargo et al. 2008) Value-in-use represents the service logic perspective. The service logic perspective is commonly known as service-dominant logic (see e.g. Vargo and Lusch 2004; Lusch and Nambisan 2015). The term service logic is also used synonymously by the same authors who introduced service-dominant logic (see e.g. Vargo et al. 2008; Vargo and Lusch 2008). In this thesis, for simplicity, the term service logic is used for showing emphasis on customer relationship for value creation in digital service innovation. Value creation refers to the interactions among providers and customers through the integration of assets and application of competences (Vargo et al. 2008). Whereas value-in-use and value-in-exchange are two widely discussed value dimensions in management literature, within IS literature, the dimension of value-in-co-creation suggests that value is created when customers engage in co-design of digital services together with firms using digital assets provided by firms (Grover and Kohli 2012).

As an organizing framework, Vargo and Lusch (2004) present eight foundational premises of service-dominant logic (see Table 1). The premises emphasize on application of knowledge and skills, active role of customers in value creation instead of being passive receivers, changing firm's role from being value producer to value proposer. In the context of digital service innovation, service logic can be applied to understand value creation. Contexts within the phenomenon of digitalization can be different and value creation is context specific (Lusch and Nambisan 2015). Recently, Lusch and Vargo (2014) argue that value is not only always co-created, but also it is dependent on assets and actors and thus is contextually specific.

Foundational Premises (FPs) of S-D logic
FP1: The application of specialized skills and knowledge is the fundamental unit of exchange
FP2: Indirect exchange masks the fundamental unit of exchange
FP3: Goods are distribution mechanisms for service provision
FP4: Knowledge is the fundamental source of competitive advantage
FP5: All economies are service economies
FP6: customer is always a co-creator of value
FP7: The enterprise can only make value proposition
Fp8: A service centered view is customer oriented and relational

Table 1. Foundational premises of S-D logic (Vargo and Lusch 2004)

The class of digital services under attention in this thesis is enabled by embedded technology in products. Less knowledge is developed that describes value creation in the case of technology-embeddedness (Kohli and Grover 2008; Nambisan 2013). The services drive incumbent manufacturing firms to make a transition from transaction oriented business to customer relationship oriented business. In this transition, the S-D logic can be of some guidance. Besides marketing literature, the implications of S-D logic have been investigated in the literature on manufacturing (Kowalkowski 2010), tourism (Shaw et al. 2011), logistics (Maas et al. 2014). Recently, S-D logic gained attention in IS. It has been argued that S-D logic can provide guidance in understanding the use of digital assets in digital service innovation (Lusch and Nambisan 2015).

3.4 The Architecture of Digitalized Product Platforms

The definition of the word 'platform' can be traced back to the sixteenth century from the examples given in the Oxford English Dictionary (OED). In the OED, platform is defined as 'a raised level surface on which people or things can stand, usually a discrete structure intended for a particular activity or operation'. In this sense 'platform' has been broadly used to describe human-built structures, dedicated to a specific use (Gillespie 2010). The word has been used as an abstract sense for a long time (Baldwin and Woodward 2009). The OED provides example from 1574 where a platform refers to 'a design, a concept, an idea; (something serving as) a pattern or model'. While the term 'platform' is used across in different literatures, the meaning of the term seems to differ between them (Gawer 2009). Two perspectives on platforms are predominant in existing literature: i) external or industry platforms and ii) internal or product platforms (Gawer and Cusumano 2014).

External (industry) platforms can be defined as products, services, or technologies developed by one or more firms, that provide the foundation upon which outside firms can develop their own complementary products, technologies, or services (Gawer 2009; Gawer and Cusumano, 2014). Microsoft Windows operating system, Linux operating system, Intel microprocessors, Apple's iPhone and iPad, Google, the Internet itself, social networking sites such as Facebook, etc. are all industry platforms (Gawer 2009). The modular architecture of the industrial platforms creates opportunity to use and reuse the components of the platforms. Based on a core component of an industry platform, different firms develop products and services. Hence, the resulting service or product may be unknown to the platform owner before the development (Gawer 2014).

Internal or product platforms can be defined as a set of assets organized in a common structure from which a firm can develop and produce a stream of derivative products (Gawer and Cusumano 2014; Meyer and Lehnerd 1997). A key difference between product platforms and industry platform is that the industry platform owners aim to use the innovative capabilities of external firms whereas product platform owners generally use firm-specific assets to innovate, i.e. they develop products internally (Gawer 2009). Product platforms are linked with the cases where firms deploy platform assets internally by imposing control in accessing the assets. Contextually, the literature on product platforms emanated from the automotive sector (Nobeoka and Cusumano 1997), although other industry contexts include consumer power tools (Meyer and Lehnerd 1997), computing industries (Meyer and Dalal 2002). Product platforms can also described using modular architecture. Firms modularize the components of a platform so that each component can be used and reused several times to produce variety of products (Meyer and Lehnerd 1997; Robertson and Ulrich 1998). The use of modularity in case of both product and industry platforms imply that in spite of the difference regarding access to platform assets, at the level of architecture both types of platforms have modular architecture to facilitate component reuse (Baldwin and Woodard 2009).

The architecture of digitalized product platforms is complex. A digitalized product platform is a set of digital and non-digital assets that enable the design of digitalized products and digital services (Meyer and Lehnerd 1997; Robertson and Ulrich 1998; Yoo et al. 2010a). Designed by manufacturing firms, digitalized product platforms consist of physical products with product modules and digital technology embedded into the modules. With the embedding of digital technology, the layered architecture of digital technology plays a significant role in the architecture of digitalized product platforms. Each digitalized product is an important component of the platform, and works as a computing platform to design digital services. Digitalized product platforms can have similar features of internal platforms. In general, product platforms developed by manufacturing firms are used internally by firms to develop products and services (Thomas et al. 2014). Digitalized product platforms also include digital technologies that can be internal to the firm. The internal development can constrain service design with customers as the platforms are not open to customers (Gawer 2009). Different strategic actions can have implications for digital innovation (Woodard et al. 2013).

The continuous use of digitalized products enables the generation of data that work as digital components on the platform. With the embedding of digital technology in physical products, the platforms' architecture follows both layered architecture of digital technology and modular architecture of physical products.

3.4.1 Layered Architecture of Digital Technology

Key to enabling digitalization of digital artifacts is their layered architecture (see Figure 2), which decouples the material from the non-material components of digital products. The layer metaphor implies that, despite the ability to separate between the different tiers in the product stack, there is a hierarchical dependence between the different strata, such that higher-level layers rely on lower-level ones for their functionality. The device layer deals with hardware and operating systems, network layer manages logical transmission and physical transport, service layer provides application functionality that directly serves users during storage, manipulation, creation and consumption of contents and finally the content layer contains data (Hylving and Schultze 2013; Yoo et al. 2010b).

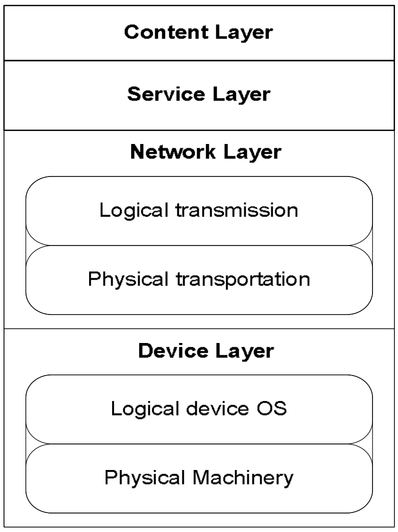

Figure 2 : The Generic Layered Architecture of Digital Technology (Yoo et al. 2010a)

The implications of the layered architecture have been studied in software platforms (Eaton et al. 2015; Tilson et al. 2013). Particularly in Apple's iOS platform, Apple exerts control over independent developers at the application functionality layer. The developers can include their application programs to the platform only when Apple allows the inclusion (Eaton et al. 2015; Ghazawneh and Henfridsson 2013; Tilson et al. 2013). This results in higher revenue for Apple without changing anything at the device layer. Another implication of the layered architecture is innovating through variety. Firms use valuable information (contents layer) with different social networking sites (application functionality layer) so that they can design various digital services (Adomavicious et al. 2008; Henfridsson and Bygstad 2013). Table 2 summarizes the implications of layered architecture on digital platforms.

Implications of layered architecture on digital platforms	
Controlling external actors	Eaton et al. (2015), Ghazawneh and Henfridsson (2013), Tilson et al. (2013)
Innovation through variety	Adomavicious et al. (2008), Henfridsson and Bygstad (2013)

Table 2: Implications of the layered architecture

In the case of a digitalized product platform, at the device layer, there is embedded digital technology that generates data, for example, a sensor embedded with the fuel tank of a vehicle. The network layer consists of physical network buses and wireless that aggregate and transport this data to the application functionality layer, which consists of both embedded and remote applications that manipulate and combine data to generate information. The top-most stratum of the stack is the contents layer, which includes information that can be presented to the customers of digitalized products (Hylving and Scultze 2013).

Before digitalization, these four layers were tightly coupled together within a particular media, industry or product boundary. Or, in the case of purely physical or mechanical products (such as furniture, car, hammer, and cloths), such layers simply did not exist (Yoo et al. 2010b). However, as a result of digitalization, these four layers will be increasingly de-coupled and thus become loosely coupled. This de-coupling is accomplished through the integration of general purpose computing capabilities The emergence of the four-layered digital service architecture has pronounced strategic and structural implications. How open and closed this architecture is and which focal firms control different parts or elements of the architecture, especially connection points between layers, have direct and significant strategic and structural implications (Yoo et al. 2010b).

3.4.2 Modular Architecture

A modular architecture is a design specification that allows decomposition of product components that can be recombined (Schilling 2000, Yoo et al. 2010a). A modular architecture also specifies the interfaces between the components and how the components interact with each other. The definition of modular architecture echoes the definition of architecture where 'an architecture specifies what modules will be part of a system and what their functions will be' (Gawer 2014, p. 1242). Modular architecture offers a way to reduce complexity and to increase flexibility in design by decomposing a product into loosely coupled components interconnected through pre-specified interfaces (Baldwin and Clark 2000; Yoo et al. 2010a). In modular architecture, the structuring of a platform into components is an intentional act to develop the capability to recombine and reuse components into new configurations (Henfridsson et al. 2009; Henfridsson et al. 2014).

A modular architecture allows flexibility and reusability (Henfridsson et al. 2009), in turn allowing product manufacturers to be flexible and also reusing product components in product manufacturing. Reusing refers to including same type of components in a set of products during product manufacturing. For example, a vehicle manufacturing firm uses a set of components that are common to a set of vehicles. Manufacturing firms use the common set of components in a set of products and add distinguishing components to create variety among the components. This reduces time in manufacturing as some components are always ready to be included. Firms can also upgrade in the components whenever necessary. This is also applicable to digitalized products where a particular digital hardware is used and reused as embedded component into a set of products. Similar to hardware, some software modules can be reused to communicate with the hardware (Garud and Kumaraswamy 1995).

A regular modular product has modules with specific predefined function. For example, an aircraft's modules, such as its wings are generally used for the purpose of lifting the aircraft (Babinsky 2003). With embedded digital sensor, each wing is enabled as a module to transmit data regarding its own condition (Zhau et al. 2007). This results in monitoring the conditions of the wings and plays significant role in the maintenance of the aircraft.

When digital technology is embedded with physical products, the products possess the layers of digital technology together with the modular architecture. Hence, the platforms are not simply physical modular platforms or software-based platforms. Rather, they become a hybrid of both modular architecture and layered architecture. This results in the emergence of layered modular architecture.

3.4.3 Layered Modular Architecture

The digitalization of modular products can be presented with a layered modular architecture continuum (Yoo et al. 2010a). A modular product prior to digitalization is basically has fixed purpose use. Consider film-cameras that were used prior digital cameras. Film-cameras have pre-defined functionalities and were only used for taking photos. With digital cameras, the usages are fluid. One can edit photos, use it as internet client and add new software to it to redesign photos and videos. The design of film-camera components follow a single design hierarchy which means that a component can be replaced with another same type of component. For example, previously used films of cameras were replaced by new films. On the other hand, with digital cameras, although the physical components (the device layer) have single design, the digital features (application functionality layer, network layer and contents layer) are designed following multiple design hierarchies. Every digital service follows different designs, for example, photo editing service, video playing/editing service, wireless connectivity service, etc. The design of photo editors is different from the design of video players. The services are sometimes designed and provided by firms that do not manufacture cameras.

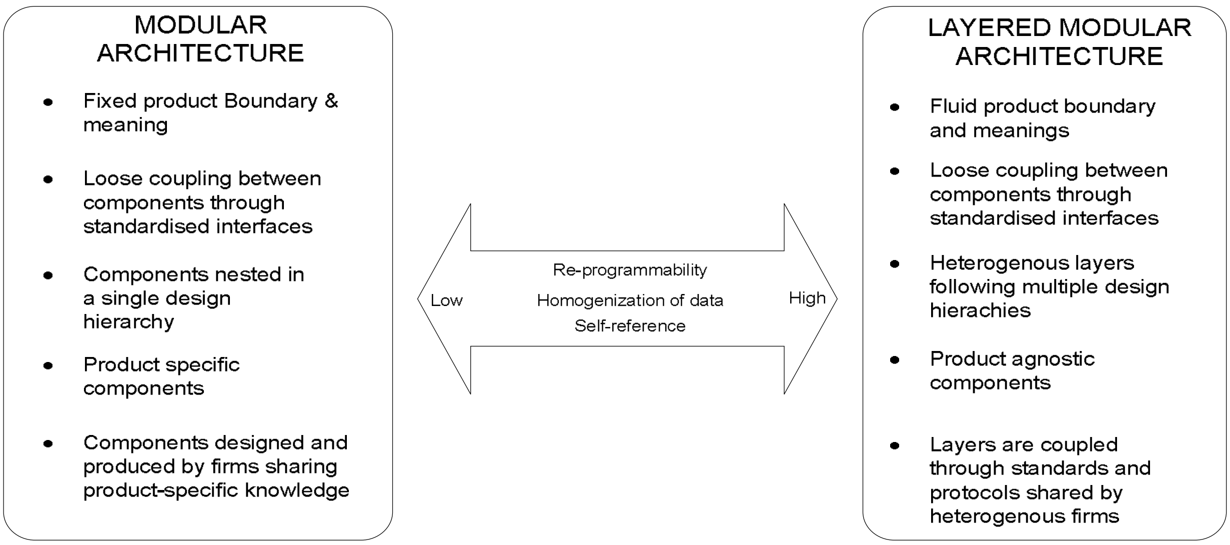

Figure 3: Layered Modular Architecture Continuum (Yoo et al. 2010a)

Figure 3 shows the layered modular architecture continuum. Due to loosely coupled components in both architectures it is always possible to reuse or replace components. The important aspect of the continuum is the low to high degree of re-programmability, homogenization of data and self-referentiality. Re-programmability allows a device to be redesigned so that different functionalities can be added. Homogenization of data allows the presentation of contents using various devices instead of a particular device as in case of analog devices. Self-referentiality means that digital technology is required for digital service innovation (Kallinikos et al. 2013; Yoo et al. 2010a).

With continuous digitalization, the degree of re-programmability, homogenization of data and self-referentiality increases. Therefore, digitalization of a non-digital modular product or service gradually takes them towards layered modular architecture. The possibility of redesigning products and services increases with digitalization. Digital technology possesses the capacity to produce unprompted change and the capacity increase with digitalization. For example, with embedded digital capability a pair of Nike shoes become information generating platforms for the wearers to calculate pace, distance, calories burned (Bettencourt and Ulwick 2008). Similarly, a digitalized vehicle gains digital capability to communicate remotely so that its location can be identified to reduce theft or its fuel consumption can be monitored (Lindgren et al. 2008; Slywotzki and Wise 2003). Digitalized products are creating paths for people to use digital services according to their needs. For example, personal mobile phones can be synchronized to the embedded phones in vehicles to facilitate risk free driving and seamless talk (Henfridsson and Lindgren 2005). The capacity of digital technology to generate change and support people in innovation is called generativity (Zittrain 2006). However, it is challenging for manufacturing firms to design generative platforms as digitalized platforms were not essential for providing previous non-digital products or services (Yoo 2010).

3.5 Generativity

Generativity is a technology's overall capacity to produce unprompted change driven by large, varied and uncoordinated audiences (Eaton et al. 2011; Remneland-Wikhamn et al. 2011; Zittrain 2006). There are a number of properties of generative technologies: leverage, adaptability, ease of mastery, accessibility, and transferability (Zittrain 2006). The properties define the functional identity and innovativeness of these technologies (Kallinikos et al. 2013). Leverage means a degree to which a technology provides help in performing certain tasks (Remneland-Wikhamn et al. 2011; Zittrain 2006; Zittrain 2008). For example, a computer can perform advanced computations (e.g., 3D simulations) in fractions of a second which is not possible with a simple calculator; hence a computer has a higher capacity for leverage. Adaptability refers to how flexible and modifiable a technology is in performing different tasks (Zittrain 2006). Besides helping us in browsing and making calls, a smartphone also serves as a camera, a music player, a video player, etc. Moreover, many apps can be added to the phone to broaden the range of its use. Ease of mastery refers to the easiness in using a technology for a broad range of users or how much skills are necessary to use the technology. For instance, it is easier to master the use of a graphical interface based operating system (e.g. Windows OS) than a command-line operating system (e.g. DOS). Accessibility means how easy it is to get access to a technology. A very expensive and patented technology has lower accessibility than an open technology, e.g., open source software. Transferability indicates how easily changes in the technology can be distributed to others (Zittrain 2008). A digital audio or video file can be easily distributed to a wide range of people.

Digital technology possesses characteristics, such as re-programmability and replicability (Benkler 2006; Eaton et al. 2011; Svahn 2012; Yoo et al. 2010a). These two characteristics can influence generativity because re-programmability is the characteristic due to which a digital artifact can be programmed and re-programmed anytime to perform different functions. Due to re-programmability characteristic, people can add new functionalities to a digital artifact at any time during its usage (Henfridsson et al. 2014; Lee and Berente 2012; Yoo et al 2010a). For example, new applications can be added anytime to an iPhone from the App Store (Eaton et al. 2011). As re-programmability is also about modifiability and flexibility of a digital technology (Yoo et al. 2010a), it is similar to the adaptability aspect of generativity (Zittrain 2008). Replicability refers to the characteristic due to which digital contents can be easily replicated. This allows replications of digital contents (e.g. music files) without fixed or marginal costs (Benkler 2006; Svahn 2012). This creates an opportunity for a person to share his or her own music/video with a large group of people. Thus replicability plays a significant role among people to produce something new and hence encourages innovation.

The loose coupling of digital modules from physical product modules enhances generative capacity. Firms can design new digital services using the loose coupling between the products and digital modules. Loosely coupled digital modules enable control over the products (Lee and Berente 2012). Moreover, due to the loose coupling in the layered architecture of digital technology, component of one layer can be used with the component of another layer. One such example is using a firm's information (contents layer) of a firm on social media (application functionality layer) so that customers can share the information (Henfridsson and Bygstad 2013). This generates new ways of building customer relationship. Because of continuous innovation in digital technologies, it is difficult for technology designing firms to predict all the possible ways digital modules can be integrated with other modules (Gawer 2009; Yoo 2013). This can be observed in digital camera industry where some cameras are integrated with Google Maps, a feature which is not included in many other digital cameras (Yoo 2013).

Physical products consist of modules that can be decomposed and recombined (Schilling 2000) and manufacturing firms are embedding digital technology in the product modules to build digitalized product platforms. These digitalized product platforms are generative as the platforms possess digital capability to enable service innovation in product manufacturing firms (Svahn et al. 2015). For example, using embedded digital devices in different modules of vehicles, vehicle manufacturing firms are re-programming the devices and providing services such as vehicle monitoring, maintenance planning, fuel consumption monitoring etc. (Andersson et al. 2008). The unpredictability of generative digital modules facilitates firms and the customers of digitalized products to use digital modules in designing new digital services. However, firms often control access to platform assets (Ghazawneh and Henfridsson 2013; Eaton et al. 2015). That can restrict generativity as customers may not have access to digital assets to design digital services. Firms are challenged to address this issue to capitalize generativity to explore business opportunities (Ghazawneh and Henfridsson 2013; Yoo et al. 2010a). This thesis will shed light on this aspect.

3.6 Summarizing Research Challenges in Digital Service Innovation

The literature review suggests that digital service innovation research can be summarized based on the research on value dimensions, architecture, and generativity (see Table 3).

Key aspects	Description	Literature
Value dimension	Three value dimensions exist in the value creation of services: value-in-exchange, value-in-use, value-in-cocreation	Kohli and Grover (2012); Lusch and Nambisan (2015); Vargo and Lusch (2004)
Architecture	Services in digitalized product platforms rely on an architecture comprising of the modular architecture of products and the layered architecture of digital technology	Henfridsson et al. (2014); Lusch and Nambisan (2015); Svahn et al. (2009)
Generativity	Generativity is digital technology's overall capacity to produce unprompted change in digitalized product platforms.	Eaton et al. (2015); Svahn et al (2015); Yoo et al. (2010a); Yoo (2013)

Table 3: Summary of key aspects in digital service innovation

With growing interest on digital platforms and platform architectures within IS (see e.g. Barrett et al. 2015; Bergvall-Kåreborn and Howcroft 2013; Henfridsson et al. 2014; Tiwana et al. 2010; Yoo et al. 2010a), particular importance has been given on the digitalization of products due to the layered modular architecture resulting from digitalization (Lusch and Nambisan 2015; Yoo et al. 2010a). With the embedding of digital technology in physical products, digitalized product platforms are created and at the same time presents some research challenges related to digital service innovation. Digitalized product platforms are built by combining digital and non-digital platform assets. One challenge is of understanding the role of architecture and assets in the platforms for digital service innovation (Barrett et al. 2015; Lusch and Nambisan 2015). In digitalization, gaining architectural knowledge is challenging for manufacturing firms as the firms need to make a transition from traditional strategies with modular architecture and gain new knowledge on the architecture of digital technology (Svahn et al. 2009). Another challenge is related to strategic and technical dimensions in digitalization. While layered modular architecture continuum emerges as result of digitalization, the technical and strategic dimensions of digital services require more attention (Yoo et al. 2010a). More research is needed to address architectural characteristics emerges from digitization and the interplay between architectural frames (Henfridsson et al. 2014). Research has been called for investigating the influence on platform modules and architectural forms (Tilson et al. 2010; Tiwana et al. 2010).

Digitalization has brought changes in the economy and the core of these changes is digitally enabled generativity (Yoo 2013). The influence of generativity has recently drawn the attention of IS community (see e.g. Eaton et al. 2015; Svahn et al. 2015). New insights are needed to guide firms in the age of generativity to replace the prevailing emphasis on modularity (Yoo 2013). Strategizing for generativity and controlling digital technological platforms present a challenge for IS researchers (Barrett et al. 2015). With increasing digitalization, it is not clear how digital assets can be controlled to facilitate the combination of various platform assets (Lusch and Nambisan 2015). Investigation is required about different combinations of digital and non-digital assets to leverage generativity of digital technology (Svahn et al. 2015). A key research challenge is the management of heterogeneous assets in designing and delivering digital services (Yoo et al. 2010a). The multi-purpose modern digital devices are combined with traditional products and the combination suggests that we need to reconsider traditional assumptions about technology's capacity (Henfridsson et al. 2014). Digitalization enables the loose coupling between content layer and device layer (Yoo et al. 2010a). The capacity of digital contents in innovation still awaits research (Kallinikos et al. 2013). Moreover, new intelligent algorithms are also influencing service innovation and much research remains to be done to understand the capacity of algorithms in innovation (Orlikowski and Scott 2015).

With digitalization and the emergence of new architecture, firms face difficulty in making a transition to new modes of value creation that requires building new digital knowledge on the existing knowledge base (Henderson and Clark 1990; Lee and Berente 2012). Customer-centric innovation with emphasis on involving customers in designing services for value creation requires special attention (Rai and Smabamurthy 2006). It is important for firms to understand the perceptions of customers for successful service innovation (Jonsson et al. 2008). For customer-centric innovation, identification of value propositions for customers using platform assets also requires attention (Lusch and Nambisan 2015). Although digital technologies are embedded with physical products, the role of technology-embeddedness in value creation is not well understood (Kohli and Grover 2008). With digitalization, as traditional businesses are changing, new value dimensions may emerge (Yoo 2010). Future research on value creation should focus on the aspect of embeddedness incorporating concepts and constructs from other business disciplines (Nambisan 2013). As value creation is context specific (Lusch and Vargo 2014), value creation of services in digitalized product platforms can be different from other contexts. For example, digitalization is affecting the increase of information as digitalized vehicles, shoes, industrial machines all are now sources of digital information (Yoo 2010). A strategy is required to leverage the information in value creation (Bharadwaj et al. 2013).

The research challenges in digital service innovation motivate this particular research. There are many challenges relating to value dimensions, architecture, and generativity in digital service innovation. This is a reason to investigate on these key aspects while conceptualizing the premises for services in digitalized product platforms.

4. Research Methodology

Every research follows a philosophical approach to achieve an understanding of a particular phenomenon. This section starts with presenting the interpretive qualitative research approach. Then, the research setting is described. Thereafter research design is presented which is followed by a description of the research process.

4.1 Research Approach

This research focuses on understanding the phenomenon of digitalization and digital service innovation. The aim of the research is to inquire into and conceptualize the underlying premises for services in digitalized product platforms. A qualitative approach was employed for this. Qualitative research can be carried out with positivist, interpretive or critical philosophical perspective (Klein and Myers 1999; Myers 1997). This thesis is based on a qualitative interpretive perspective. A qualitative approach is useful in exploring new socio-technological phenomena and gaining an understanding from the viewpoints of the participants (Kaplan and Maxwell 2005). It is also useful for understanding the particular context within which participants act (Maxwell 1997). The aim of the thesis is to contribute to knowledge by conceptualizing the premises for services in the context of digital service innovation in the vehicle industry. The rationale behind choosing a qualitative approach in this research was twofold. First, I wanted to gain better understanding of digitalization of products and digital service innovation as a socio-technological phenomenon. Second, I wanted to get the viewpoints of multiple stakeholders involved in digital service innovation in a natural setting.

From an interpretive perspective, knowledge of reality, including the domain of human action, is gained through social constructions (Klein and Myers 1999; Walsham 1993). Interpretive research focuses on the complexity of human sense making as the situation emerges (Kaplan and Maxwell 2005; Myers 1997). An interpretive researcher examines the phenomenon of interest in its natural setting and from the perspective of the participants. The design and use of information technology is intrinsically implanted in social contexts. Neglecting the social contexts gives an incomplete picture of a socio-technological phenomenon (Orlikowski and Baroudi 1991). I studied digitalization and digital service innovation in the setting where digital service innovation was going on. This allowed me to investigate digitalization and digital service innovation in its natural socio-technical setting.

Klein and Myers (1999) have presented a set of principles for conducting interpretive IS research (Table 4). These principles have been used as guidelines for conducting and evaluating interpretive IS research (see e.g. Holmström 2004; Jonsson 2010; Sandberg 2014; Åkesson 2009). In the following section, I discuss how these guidelines were applied to my research. The first principle is the principle of the hermeneutic circle. The hermeneutic circle suggests that the understanding of the whole context is dependent on its parts. The research process in this thesis has been an iterative process between parts, such as empirical details of remote diagnostics technology and services, and wholes, such as knowledge on digital service innovation. The thesis is divided into two sections, five individual papers that function as parts to support the cover paper which constitutes the whole. The cover paper and the individual papers reflect the interpretive process in order to understand services in digitalized product platforms. In the papers, I address value dimensions, architecture, and generativity. Researching these key aspects was useful to conceptualize services in digitalized product platforms. The findings reported in papers were iteratively used to make an understanding on services in digitalized product platforms.

1. *The fundamental principle of the hermeneutic circle* This principle suggests that all human understanding is achieved by iterating between considering interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all other principles. 2. *The principle of contextualization* Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged. 3. *The principle of interaction between the researchers and the subjects* Requires critical reflection on how the research materials, or data, were socially constructed through the interaction between the researchers and participants. 4. *The principle of abstraction and generalization* Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action. 5. *The principle of dialogical reasoning* Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tells") with subsequent cycles of revision. 6. *The principle of multiple interpretations* Requires sensitivity to possible differences among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts even if all tell it as they saw it. 7. *The principle of suspicion* Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.

Table 4: Principles for conducting and evaluating interpretive research (Klein and Myers 1999)

The second principle relates to the context of the research setting. The research context, digital service innovation in the vehicle industry, is presented in the cover paper. A detailed description of the research setting is presented in the cover paper and in the individual papers. The description provides the background of the research project that aimed at developing the technology that enables the design of digital services. This thesis also provides information on the vehicle manufacturing firm that initiated the project where I actively participated.

The third principle relates to the interactions between the researcher and the participants. The research process for this thesis was designed so that two researchers conducted the data collection. Although we had different overarching research questions, this process gave us the opportunity to continuously discuss and reflect upon our presence at the research site, the data collection and our interpretations. In interacting with people in the studied context, I clarified my role as a researcher and sought permission to record their comments during the empirical activities. Data was in most cases collected at the participants' workplaces to provide a familiar atmosphere for the participants. I also gained feedback on my interpretations from the participants.

The fourth principle relates to abstraction and generalization. In this research, I started with an exploratory mindset to learn about the context. This exploration guided me to choose the concepts that were appropriate to collect and interpret the data. For example, I applied the concepts of layered modular architecture to investigate the architectural characteristics. There are basically four ways of generalizing (see e.g. Walsham 2006). In this study, the generalization was done by developing concepts specific to services in digitalized product platforms, and by deriving specific implications for digital service innovation.

The fifth principle relates to dialogical reasoning. I started the research with preconceptions about digital services from my prior knowledge. I gained knowledge on digital services from the literature during the research. During the study, I reflected upon my preconceptions by engaging in discussions about the findings with the co-authors. The findings from the research contradicted my preconceptions of digital services. The interpretations during this research were not limited to theoretically informed concepts, rather open for new themes.

The sixth principle relates to multiple interpretations. In conducting the research, I collected data from different participants with different roles that would allow multiple interpretations. For example, participants with different roles were asked a set of interview questions. This allowed me to record a range of perspectives, from the views of customers, to technical insights and managerial opinions. The views allowed multiple interpretations.

The seventh principle relates to the principle of suspicion. It suggests that researchers should carry out research critically. In this research, I collected data from different sources so that I can verify one source of data with other sources of data. For example, I read published scientific papers on remote diagnostics technology after interviewing engineers and computer science researchers regarding the technology. When further clarification was needed, I corresponded with them via emails or conducted follow-up interviews. Similarly, I interviewed people with different roles within the companies that were target customers of remote diagnostics services.

4.2 Research Setting

This research is part of a large action research project between a vehicle manufacturing company, SmartBus, and a group of researchers from Halmstad University. Engineers and service business developers from SmartBus, computer science researchers, and information systems (IS) researchers from the university were involved in this project. The project activities began in early 2010 with the development of the technology. As one of the IS researchers, I took part in the project from August 2010 to June 2013. According to the project plan, the service design part of the project ended in June 2013 and the technology development and testing continued until the end of 2013.

SmartBus is one of the largest vehicle manufacturing firms in the world. Historically, SmartBus's business focuses mainly on selling vehicles. In addition, SmartBus also provides maintenance services once their vehicles are sold. The firm has different business areas such as product design, product manufacturing, technology development, maintenance service development, etc. The firm's turnover from maintenance services has not been satisfactory. To find a remedy to this problem and become more customer oriented, SmartBus strategized to expand business towards digital services. Therefore, a project named RDS was initiated to develop technology for providing state-of-the-art services related to vehicle maintenance. During this project, digital services enabled by remote diagnostics platform were called Remote Diagnostics Services (RDS). The RDS project was an endeavor to bring innovation in maintenance services. However, with a business dominated by vehicle sales and little knowledge of customer needs from digital services, SmartBus faced challenges when designing RDS. This created an opportunity for me as an IS researcher, to investigate RDS.

In this project, SmartBus aimed to build a digitalized product platform in the form of a remote diagnostics platform. To build the platform, the following assets were required: i) a fleet of vehicles, ii) digital assets iii) experts' knowledge to work with digital technology, and iv) knowledge gained from target customers. Digital assets include embedded digital devices in vehicles, data generated from vehicle usage, networking technologies, an algorithm at the back-office to analyze the data. Each vehicle was digitalized by embedding devices that assisted in collecting data from the vehicle's parts, analyze the data and transmit it to SmartBus's back-office. Experts at the back office gather data from all vehicles in the fleet and further analyze it using an algorithm to check deviation. The analysis could lead to predicting faults. One important feature of this platform was that the vehicles were owned by the customers whereas SmartBus had full control over the digital assets.

The project had two parts with two specific aims. One aim of the project was the 'technology development part' to develop remote diagnostics technology for buses and the other was the 'service design part' to design remote diagnostics services (RDS). I was involved in the service design of RDS. RDS aimed at fault diagnosis and prediction. The remote diagnostics technology was applied on a fleet of vehicles (city buses) of a public transport operating company (PTOC). The PTOC was a customer of SmartBus. The diagnosis and prediction service was conducted using embedded digital devices in each vehicle in the fleet. Each embedded device collected signals from different parts a vehicle and was capable of doing onboard signal analysis.

Analyzed signals from each vehicle in a fleet were transmitted wirelessly to a remote station. Using a pattern seeking algorithm, experts at the remote station sought for a deviation pattern in the fleet. If signals received from any vehicle showed deviations, the reason for deviation was identified. With a possibility to predict faults, remote diagnostics technology created opportunities for SmartBus to design digital services related to vehicle maintenance and operations, and offer the services to their customers.

The service design part had two phases: *exploration phase* and *service conceptualization phase*. The exploration phase aimed at identifying challenges and opportunities of remote diagnostics technology and identifying customers' needs from RDS. The service conceptualization phase aimed at conceptual design of remote diagnostics services. The initial activities were concerned with exploring customer needs. The service conceptualization phase began in the beginning of 2012, and from 2012 to 2013 the activities iterate between exploration and service conceptualization. The services that were conceptualized include error notification, driver behavior monitoring based on fuel consumption, maintenance service scheduling, and fleet scheduling.

4.3 Research design

The design of this research consists of five interconnected components: goals, concepts, research question, methods, and validity (Maxwell 2005). The design did not proceed through a sequence of steps; rather it was an ongoing process that involves going back and forth between different components of the design. As a part of a collaborative research project with SmartBus, there were practical as well as research goals. One practical goal was to conceptually design digital services, namely remote diagnostics services enabled by digitalized vehicles. The service conceptualization was based on exploration of current business and customer needs. The research goal of my thesis was to conceptualize the premises for services in digitalized product platforms. The practical goal had a role in setting the intellectual goal.

As SmartBus was expanding business by including digital services to vehicle sales, literature on evolution from goods-centered business logic to service-centered business logic provided guidance for this research. SmartBus's business had similarities with goods-centered business logic and the firm faced challenge of carrying out digital service innovation with the business logic. SmartBus was creating digitalized product platforms with the digitalized vehicles. A new architecture was emerging due to the embedding of digital technology in SmartBus's vehicles. As it was a case of digitalization of vehicles, the literature on digital innovation and platforms was also used. The literature reviews guided me in finding challenges regarding architecture and generativity in value creation. Therefore, I aimed at conceptualizing the underlying premises for services in digitalized product platforms following the aspects of value dimensions, architecture, and generativity. Based on the aim, I set my research goal by formulating the following research question: "what are the underlying premises for services in digitalized product platforms?"

The concepts chosen for the research are connected to the goals and research question. The research setting relates to digitalization and creating new digitalized product platform combining physical product architecture with the layered architecture of digital technology.

Therefore, the concepts of modular architecture and layered modular architecture were used for guiding the data analysis of this research. The remote diagnostics technology possesses the capacity of generating digital data and enabling service design. This inspired me to use the concept of generativity in this thesis. Value perspectives relating to value-in-use and value-in-exchange were particularly drawn to understand value creation of digital services as well as to analyze data. I used different concepts in individual papers included in this thesis. Different theoretical concepts can provide rich insights into a phenomenon (Walsham 2006).

This research followed multiple data collection methods. Applying different methods can be useful to generate a comprehensive understanding of a phenomenon comprising of different aspects (Mingers 2001). Digitalization of products and digital service innovation are also comprised of aspects of architecture, generativity and value. In this interpretive research, I have used a number of different data collection methods including meetings, interviews, workshops, and documents. The data collection methods were conducted in parallel with findings from one method was fed into another method. For example, findings from meetings on architectural aspect were useful in preparing interview questions. Similarly, findings from interviews were useful while analyzing documents.

In qualitative research, validity does not imply any objective truth; rather validity in qualitative research is about intensive involvement, rich data and respondent validation (Maxwell 2005). For this research, I was actively involved for three years in a project with a vehicle manufacturing firm in digital service innovation. I actively took part in the conceptualization of services in a digitalized product platform. I collected data using different methods and regarding aspects of digitalization. Data was collected not only from the people of the manufacturing firm, but also from target customers of digital services. I did respondent validation or member checking by sending emails to clarify my understanding and presenting my findings in front of the participants.

4.4 Research Process

The research process is described using the following steps: gaining and maintaining access, style of involvement, data collection and analysis (Walsham 1995; 2006). The following sections will illustrate these steps. The whole journey of my PhD studies is shown in the Figure 4.

2010	2011	2012	2013	2014	2015
• Admitted as a PhD student in July • Started working actively on SmartBus's RDS project • The exploration phase of the project began with monthly project meetings, workshops and interviews • Started reviewing literature on digital innovation and business logic	• Monthly meetings with project members • Service design meetings began • Paper 1 published • More interviews with SmartBus personnel • Data analysis began in parallel with data collection	• Monthly meetings • Service conceptualization began during interviews and workshop with target customers • Service conceptualization in service design meetings • Exploration was going on with target customers and SmartBus representatives	• Monthly meetings • Additional interviews with traget customers to understand value of RDS • Interviews with project engineers to understand architectural characteristics • Paper 2 published • A set of service concepts were designed • Project ended with the presentation of the findings	• Paper 3 published • Follow up interviews with the interviewees • Paper 4 was published • Analyzing data to get a holistic picture of services in digitalized product platforms	• Theoretical elaboration • Paper 5 submitted • Cover paper completed with main contribution

Exploration phase of the RDS project

Iteration between exploration and service conceptualization phases of the project

Figure 4: The PhD research process

4.4.1 Gaining and Maintaining Access

For my research, it was essential to meet different business area representatives of SmartBus to understand the business logic of SmartBus and their views on service innovation based on RDS. During the project, I took the opportunity to interview five business area representatives; one of them was interviewed twice. I also conducted workshops with three of the representatives. At the end of the project, I presented my findings in a seminar organized by the project manager and all the people that I interviewed were invited to the seminar along with other stakeholders of SmartBus. They provided feedback based on my presentation.

In my research, another important aspect was to gain access to customers of SmartBus and identify target customers that could use RDS. It was important to understand the target customers' needs around RDS as customers could provide valuable insights to design RDS. To gain access to current customers of SmartBus and target customers for RDS, I had the following strategy. When SmartBus decided to deploy the remote diagnostics technology in a fleet of buses of a customer (a public transport operating company), I took the opportunity to visit the site multiple occasions, observed how the devices were installed in buses and interviewed the employees of the company. I also gained access to two other public transport operating companies and the local transport authority. The access was used for learning about their current operations, their ways of dealing with vehicle maintenance, the kind of technologies they had for their daily operations, their views on RDS. Together with three of my colleagues at Halmstad University, I conducted a workshop with four employees of a public transport operating company.

4.4.2 Style of Involvement

Walsham (2006) describes two roles of a researcher in an interpretive research: outside researcher and involved researcher. An outside researcher carries out research without direct involvement in the action. On the other hand, an involved researcher tries explicitly to change things in the way that he/she feels best. I was closely involved with the service design part of the project to understand customer needs from RDS and conceptual design of RDS. I actively participated in problem identification with practitioners and took actions for finding solutions for the problems by conceptually designing RDS. I started working in the project when SmartBus officially started the service design part of the project.

There were some advantages of working as an involved researcher. First, together with the project members from SmartBus, I got the opportunity to discuss the current business scenario with the business area representatives and some other employees of SmartBus who were involved in vehicle maintenance. Discussing with the SmartBus employees provided a better understanding of current business, problems in the business and opportunities for remote diagnostics in the business. Gaining insights from the SmartBus employees became easier due to my close involvement with the project. Moreover, due to this close involvement, I came to know about the customers of SmartBus that later acted as target customers for RDS. As I was not directly involved with the technology development part of the project, I was working as an outside researcher for that part of the project. When I started working on the project, SmartBus engineers were already started working on remote diagnostics technology. I got the opportunity to know about the technology from the project description. Later, I analyzed scientific papers and reports written by the engineers and computer science researchers involved in the project. I followed the progress in the technology development during the project meetings. I also had various interactions with the engineers and computer science researchers of the project through interviews and emails. The interactions were useful in gaining in-depth knowledge about the technology.

4.4.3 Data Collection

The sources of data collection were meetings, workshops, interviews, and documents (see Table 5). The data collection activities were included in two iterative phases of the service design part of the project: *exploration* and *service conceptualization*. The *Exploration* phase was about understanding current business, finding opportunities for RDS business, identifying customer needs from RDS. The *Service conceptualization* phase dealt with designing service concepts using customers' knowledge. Concepts of service logic, layered modular architecture, and generativity provided guidance during the different activities of data collection.

Data Source		Description
Project meetings	Monthly meetings	20 meetings. A meeting normally had a duration of 2-3 hours
	Service design meetings	30 meetings. A meeting normally had a duration of 2-3 hours
Interviews		31 interviews. Interviewees include business area representatives of SmartBus, representatives of public transport operating companies (PTOCs), computer science researchers and engineers, and service developers of SmartBus
Workshops		3 workshops with SmartBus representatives 1 workshop with project members 1 workshop with representatives from a PTOC 2 workshops with service developers to design business models
Documents	Project proposal	A project proposal written by a group of SmartBus staff
	Technical reports	6 reports regarding the projects written by the engineers and computer science researchers of the project
	Short reports on project updates	53 reports sent by the project manager regarding the updates on the project.
	Final project report	A report written by all project members
	Market analysis report	A report prepared by service developers to compare existing vehicular diagnostics technologies
	Emails	113 e-mail correspondences between project members

Table 5: Overview of data sources

Project Meetings

Data collection for this research started with the project meetings. Project meetings have been considered as one of the sources of data collection in IS research (Benbasat et al. 1987; Dennis and Garfield 2003; Nandhakumar and Jones 1997).

There were two types of meetings during the project: monthly project meetings and service design meetings (see Table 6). A monthly project meeting normally lasted for 2-3 hours. There were twenty monthly project meetings. The meetings were audio recorded and meeting notes were taken. The engineers and computer science researchers used to present their latest findings in the beginning of a monthly project meeting. After their presentations, the service developers, informatics researchers (including myself) and the project manager used to ask questions. For example, I discussed with them about business implications of their findings, how their analyses can solve customers' problems with vehicle maintenance, what the potentials of the generated data from vehicles are. I discussed about business logic for RDS. For example, I discussed the role of the firm (SmartBus), how SmartBus as a provider of RDS could do business with customers and SmartBus could create value for customers and/or for themselves.

Monthly Project Meetings		
Participants	**Activities**	**Purpose**
• Informatics researchers (3) • Computer science researchers (3) • Project manager • SmartBus's engineers (3) • SmartBus's service developers (2)	• Discussions on current business scenario and future vision • Presentation of technical findings by the engineers and computer science researchers • Presentation by informatics researchers and service developers on the exploration of customer needs and service conceptualization • Discussions on problems in technology development and possible solutions to the problems. • Discussion among all project members regarding the possible businesses with remote diagnostics services	• A general understanding of product-oriented business and expansion towards digital service business • A general understanding of digitalization of vehicles with embedded digital technology and the architectural characteristics of digital services • An initial understanding regarding the value of digital services for SmartBus • An understanding regarding the capacity of digital technology • An understanding of the challenges with the remote diagnostics technology
Service design meetings		
Participants	**Activities**	**Purpose**
• Informatics researchers (3) • SmartBus's service developers (2)	• Identifying business area representatives of SmartBus to gain insights of SmartBus's business • Identifying target customers for RDS • Arranging interviews and workshops with business area representatives and customers • Exploring customer needs from RDS • Discussions on findings from interviews and workshops • Service conceptualization • Business model design	• Further understanding of business challenges and opportunities for expanding business by including digital services to product sales. • An understanding regarding value of RDS both for customers and SmartBus

Table 6: Details on meetings

The engineers and the manager were employees of SmartBus and, their views about business opportunities with RDS were important because they expressed their views as the representatives of SmartBus. Specifically, the project manager was appointed by the top management of SmartBus to manage the project and he had regular contacts with the top management to understand their views on business implications of remote diagnostics technology. He shared the views of the top officials in our monthly project meetings. In every monthly meeting, after the technical members' presentations, service developers presented their latest findings of their activities. For example, when I conducted interviews or workshops with target customers and SmartBus employees, I presented my findings from the interviews.

Another type of meeting was the service design meetings. In these meetings, service developers from SmartBus and informatics researchers met, identified target customers and internal SmartBus employees, discussed findings from the interviews and workshops with the target customers and employees, identified opportunities with RDS, and conceptually design RDS based on customers' needs. The meetings were arranged by service developers or informatics researchers on an on-demand basis. The main aim of service design meetings was to conceptually design remote diagnostics services (RDS). As one of the IS researchers, I participated in the meetings and contributed in the conceptual design of RDS. The notes from monthly meetings were sources of valuable information for the service design meetings. For example, the presentations by engineers and computer science researchers in the monthly meetings provided a better understanding to the service designers about remote diagnostics technology. Following the service blueprinting technique by Bitner et al (2007), RDS were designed conceptually. The purpose was to conceptualize business opportunities with RDS by identifying solutions to customers' problems and ways of expanding business from vehicles sale to digital service offerings for SmartBus.

In the meetings, the service developers and I took part in the conceptual design of the remote diagnostics services. The conceptual design was done based on customers' needs identified during the workshop and interviews with customers. Four remote diagnostics services were conceptualized: error notification, driver behavior monitoring based on fuel consumption, maintenance service scheduling, and fleet scheduling.

Interviews

I conducted 31 interviews in total (see Table 7). The interviews were semi-structured in nature and designed using the guidelines by Myers and Newman (2007). For example, Myers and Newman (2007) suggested the use of mirroring questions and answers, i.e., constructing subsequent questions based on an interviewee's comments. This was done during the interviews by phrasing the interview questions by focusing on the interviewees' responses.

Each interview was 1-2 hours long. The interviews were audio-recorded and transcribed. To conduct interviews, I prepared interview questionnaire. While preparing the questionnaire, I prepared empirical definitions of the concepts using terms from the industry. I asked follow-up questions via emails to clarify some of their comments during interviews. I started interview activities with the business area representatives of SmartBus to get an understanding of the current business of SmartBus. SmartBus has different business areas such as product (vehicle) development, technology development, maintenance service development etc. I asked the representatives questions regarding the current ways of conducting businesses, their views on remote diagnostics, and service business opportunities with remote diagnostics.

The interviews with representatives from maintenance service development gave me an in-depth idea on how vehicle maintenance business works and the opportunities with RDS. *Six* interviews were conducted with the business area representatives. Engineers and computer science researchers who were involved in the project were also interviewed. Their interviews provided a deep understanding of the architecture of the remote diagnostics platform. The understanding was useful in finding out the strengths and limitations of the technology. I also asked them about their views of business opportunities regarding remote diagnostics services. The project manager was interviewed twice. He provided information about SmartBus's existing business logic of vehicles and maintenance services. As he himself was working as an engineer, he also provided insights about the technology. There were *twelve* interviews with computer science researchers and engineers that included two with the project manager. I conducted *three* interviews with SmartBus employees who were involved in service design part of the project. As I was also actively involved in the service design part, I often had meetings with them. However, the interviews were specifically relevant to understand the current business of SmartBus and future business opportunities with RDS.

Interviews		
Interviewees	**Activities**	**Purpose**
Business area representatives of SmartBus	• Asked questions regarding the current business of SmartBus, problems with existing business, different customer segments, challenges and opportunities with RDS, potential value of RDS for customers and SmartBus, etc. • Asked questions regarding current digital and non-digital assets, challenges and opportunities with digital assets, such as remote diagnostics	• An understanding of product-oriented business • An understanding of the challenges of expanding business towards digital services. • An understanding of the value of expanding business by including digital services to product sales.
Representatives from public transport operating companies (PTOCs)	• Asked questions regarding PTOCs' business operations, experience with RDS, possibilities with remote diagnostics, etc. • Asked questions regarding potential value of remote diagnostics	• An understanding of customer needs, value of digital services from customers' points of view • An understanding of implications of platform generativity to customers
Computer science researchers and SmartBus's engineers	• Asked questions regarding technical characteristics of remote diagnostics, limitations and opportunities with the technology • Asked questions related to the layers of digital technology	An understanding of the architectural characteristics of digital services enabled by embedded technology
Smartbus's service developers	• Asked questions regarding possible business opportunities with digital services • Asked questions regarding current digital and non-digital assets resources, challenges and opportunities with digital assets, such as remote diagnostics • Asked questions regarding potential value of remote diagnostics	An overall understanding of opportunities with digital technology to carry out digital service business.

Table 7: Details on interviews

I interviewed representatives from three public transport operating companies (PTOCs), which were the target customers for RDS. The main purpose of the interviews with the PTOCs was to understand the current problems they had in regards to vehicle maintenance and repair. SmartBus was using the remote diagnostics technology to monitor and diagnose problems of nineteen buses of a PTOC. The PTOC is named as K-Transport (a pseudonym) in this thesis. K-Transport had service contracts with SmartBus and did not have their own maintenance workshop. Therefore K-Transport was highly dependent on SmartBus for maintenance services. Three managerial personnel of K-Transport were interviewed. Four drivers were also interviewed. I also interviewed personnel of two other PTOCs, N-Transport and A-Transport (both pseudonyms) that had their own maintenance workshops and hence did not depend on SmartBus for maintenance services even if they used buses manufactured by SmartBus. During these interviews, questions were also asked about their experiences regarding existing digital technologies for their day-to-day operations and opportunities with remote diagnostics technology in their activities. I conducted *ten* interviews in total with the representatives of the PTOCs. The information gathered from the interviews was used in the conceptual design of RDS.

Workshops

As part of the exploration phase, three workshops were held with the business area representatives of SmartBus (see Table 8). During each workshop, beside a business area representative and myself, a service developer from SmartBus and an IS researcher was present. The main aim of the workshop was to draw the business networks of SmartBus. For example, a workshop was conducted with a SmartBus representative who worked within the business area of vehicle management services. Vehicle management services aim to ensure effective operations of customers such as PTOCs. In the workshop, the representative drew the networks of the business. The network shows the partners, activities and customers. The drawn networks were useful to identify the type of customers involved in the business. This identification was later used for contacting the target customers for RDS and interview them.

Similarly, two more workshops were conducted with two different business area representatives. These two representatives were different from the first representative because the first representative was working at the headquarters of SmartBus and dealing with global business issues. However, the two other representatives were dealing with developing products in regional markets. The representatives identified different business challenges and expressed different views on business with RDS. The networks of their business were also different. Four more workshops were conducted as part of service conceptualization phase of the service design part. The first of the workshops in the service conceptualization phase was conducted with the employees of N-Transport. The employees include a traffic manager, two drivers and a maintenance service technician. They collaborated in the conceptual design of services that they require to fulfill their needs. The second workshop was conducted with the project members who envisioned different scenarios where RDS could be deployed. The third and fourth workshops were conducted with service developers to design business models for RDS focusing on different customer segments. The first and second workshops in the service conceptualization phase were video recorded. Discussions during the other workshops were audio recorded and notes were also taken.

Workshops		
Participants	**Activities**	**Purpose**
3 workshops with Business area representatives of SmartBus	• Drawing business networks • Identifying customers for RDS	A general understanding of the network of a product-oriented business
1 workshop with the representatives from a PTOC	Visualizing the uses of RDS in the PTOC's business operations	An understanding of applying digital assets for service co-design with customers
1 workshop with the project members	Visualizing various uses of RDS for service conceptualization	An understanding of technology's generativity
2 workshops with service developers	Designing business models for RDS business	An understanding of key platform assets and their usages, value propositions, key activities for RDS

Table 8: Details on workshops

Documents

Data was collected from the project related documents (see Table 9). As an active project member, I had access to project documents. Throughout my involvement in the project, I kept track of the project reports prepared by project members and e-mail correspondences between the members. I also requested for documents that I considered important for my research.

The first related document was the project proposal. I analyzed two technical reports prepared by the technical members (engineers and computer science researchers) of the project who presented the reports to the project members as well as to the managerial staff of SmartBus. Project related articles were written by the engineers and computer science researchers, and published in peer reviewed academic journals. I analyzed two published articles. These documents worked as the supplements to the interviews with the technical members. I received 53 short reports on project's progress from the project manager where he summarized all ongoing activities by the project members. These reports were known as weekly reports because the reports used to summarize the weekly activities of the members. E-mails were useful in understanding some unclear parts of the project. I asked questions that were relevant to my research aim. Besides that I used to receive emails related to the project that included information of any customer or any competitor. I used 113 emails for my research. I also analyzed three press releases of SmartBus.

Documents		
Type of document	**Quantity**	**Purpose**
Project proposal	1	To gain an overview of the project aims
Technical reports	6	To gain understanding of the technology that complemented the data collected from engineers and computer scientists regarding the architectural characteristics of digital services
Short reports	53	To gain complementary knowledge regarding technology and business
Final project report	1	To gain an overall understanding of the project's outcome.
Emails	113	Used for continuous communication with project members and interviewees for clarification of their comments and views.
Press Releases	3	Used for receiving latest news about SmartBus's digital service innovation

Table 9: Details on documents

4.4.4 Data Analysis

Data was analyzed in three steps: data reduction, data organization and conclusion drawing (Miles and Huberman, 1994). Data reduction took place while identifying and coding data relevant for this research. Themes from existing literature were used for reducing data from the large dataset. It occurs during summarizing, paraphrasing and coding transcripts. It was not about quantification rather it was about making selection of data from a large dataset. Once data was coded, the next step was to organize the data, generally using the themes that were used for data reduction. Tables were prepared for the data organization. Conclusion was drawn by comparing the organized data again with the themes that was used for data reduction. The comparison reduced bias in decision making. The three steps of data reduction, data organization and conclusion drawing took place in parallel.

Some of the data sources used in this research covered a broader perspective than my research. For example, the project documents that were used in my research were prepared by different SmartBus employees and dealt with various aspects of the project. Therefore, I selected the parts that were significant for my research. Similarly, project meetings were often concerned with different issues within the project. Moreover, as all the interviews were open-ended, the interviewees had freedom to respond to a question in the ways they wanted. The interviews also produced empirical material that was broader than the scope of my research. Therefore, data reduction was necessary to acquire data that was more focused on my research.

The strategy followed for coding the data was concept-driven thematic coding (Braun and Clark 2006; Constantiou et al. 2014). The coding of data was driven by concepts used in this research. For example, as an aspect of digitalized product platform, data on architecture was very important for this research. To analyze the project documents, meeting notes and workshop materials, I applied layered architecture and layered modular architecture concepts for the selection of data regarding architecture. As layers consists of device layer, network layer, application functionality layer, and contents layer, I searched for the sections in data that discussed about embedded devices, algorithm or generated data from vehicles. The searching provided an overall picture of the layers of remote diagnostics technology. I applied the same strategy on the meeting notes. Similarly, the notes from meeting were analyzed to search for data on the layers of remote diagnostics technology. Interviews with engineers and computer science researchers were focusing on technological details. Valuable data on digital layers were identified from their interviews as they were asked questions on architectural layers during the interviews.

For searching data on value aspects, interviews and workshops with business area representatives acted as the starting point. Interview statements on benefits of RDS were useful in the coding of data. Notes and statements from meetings and interviews with project members were analyzed to find out data on digital and non-digital assets, strategies with assets in developing business and making value propositions. Interviews and workshop material with customers were analyzed by selecting data that illustrate their needs, their understanding of the technology, their knowledge and capability, the possible benefits of RDS for them.

Technological capacity was described in documents and discussed during meetings and interviews with engineers. The discussion was a good source for data on generativity. While investigating on generativity, special emphasis was placed during the analysis of data to identify interview statements, meeting notes that discuss on technological capacity and strategy to use the capacity. Moreover, data collected from customers were also analyzed with an aim to identify their views on applying technological capacity in their business.

During the selection of data for this particular research from the dataset, a simultaneous step was to organize the data for visualization. Although data reduction yields useful data, the data was still required to be organized in a certain way. Otherwise, the selected data would be spread around in different empirical material such as, interview transcripts, project documents, meeting notes. Data was organized in tables following the concepts used for this thesis. For example, different visualization approaches were used to organize data for the aspects of value dimensions, architecture, and generativity. For instance, while investigating value, data was organized to visualize digital assets, customer needs, and value propositions. This organization was driven by my interpretation. I used Excel sheets to make the visualization maps. The co-authors of the papers were also involved in making interpretations of the data.

After organizing the data, the final task was to elaborate the premises for services in digitalized product platforms. To do this, I analyze the data to find out a holistic picture comprising the three aspects, value dimensions, architecture, and generativity. Interpretation regarding these three aspects played the role of parts to understand the whole, i.e. premises for services. Relationship was identified between the aspects to formulate the underlying premises for services that can describe the role of architecture and generativity in value creation. The activities included finding out common pattern in the data, comparing with the concepts used for analysis to identify similarities and differences, getting feedback from informants by sending out emails etc.

5 Research Contributions

This thesis builds on a collection of five research papers. Three of the papers are published in international conferences. One is published in an international journal and another paper is under review in an international journal. The next section summarizes the individual papers and provides an overview of their relationship to the overall contribution of the thesis. After presenting the papers, I present the premises for services in digitalized product platforms. Thereafter, I present the theoretical implications of the premises.

5.1 Summary of Research Papers

Paper 1: Chowdhury, S. and Åkesson, M. (2011). A Proposed Conceptual Framework for Identifying the Logic of Digital Services, In the *Proceedings of the Pacific Asia Conference on Information Systems (PACIS),* Brisbane, Australia.

In this paper, a conceptual framework is presented to identify the logic of digital services. The significance of this paper in my thesis is that it conceptualizes the role of architecture in value creation. The paper conceptually shows how aspects of architecture are related to the aspects of value. Existing literature in IS addresses layered architecture of digital technology and modular architecture of physical products. The service literature describes value from goods logic and service logic perspectives. However, the relationship between architecture and value in digitalization is relatively unexplored. The conceptualization made in this paper is an attempt to illustrate the relationship between architecture and value and it is based on the concepts of the layered architecture of digital technology, layered modular architecture continuum and the two business logics, goods logic and service logic. The conceptualization shows that the characteristics of modular architecture are related to firm centric value creation. For example, modular architecture is characterized by product specific components and fixed product boundary. This implies that manufacturing firms determine the use of the manufactured products which are difficult to redesign due to the low possibility of re-programmability. Manufacturing firms produce the products and define the use of the products with little possibility to involve customers in redesign. Therefore, customers act as the receivers of the products. This is similar to embedded value or value-in-exchange. On the other hand, layered modular architecture is characterized by fluid use and multiple design possibilities. Therefore, a product or service designed with layered modular architecture can be easily reprogrammed and redesigned according to customer needs. Therefore, it is possible for customers to co-design the services. This implies that layered modular architecture enables value co-creation with customers.

Paper 2: Chowdhury, S. and Akram, A. (2013). “Challenges and Opportunities Related to Remote Diagnostics: An IT based Resource Perspective”, *International Journal of ICT and Human Development (IJICTHD)*, 5 (3), pp. 80-96

In this paper, the business challenges related to remote diagnostics are presented. The role of this paper in my thesis is that it argues for customer relationship in digital service innovation. Moreover, the paper presents challenges of building digital assets. The paper presents the early stage of empirical findings with the firm SmartBus. SmartBus traditionally has been following transaction based business. The firm faces challenge while expanding business towards customer relationship oriented digital service business using embedded digital technology in physical products. The paper provides empirical observations that show the importance of framing a specific logic for conducting business with digital services with digitalized products. It shows that establishing a customer oriented business is challenging for a manufacturing firm that focuses mainly on products sale. However, when customer assets such as vehicles are digitalized, it opens up an opportunity to have a real-time communication with customers. This real-time communications may lead to a new customer relationship.

Paper 3: Chowdhury, S., Bergquist, M. and Åkesson, M. (2014) “Architectural Characteristics of Digital Services Enabled by Embedded Technology: A Study on Remote Diagnostics Services”, in the Proceedings of *the Hawaii International Conference on System Sciences (HICSS), USA*

In pursuit of conceptualizing services in digitalized product platforms, one of the aims of my research was to explore the architectural characteristics of digital services. While Paper 1 conceptually presents the relationship between architecture and value, Paper 3 presents an empirical account of the architectural characteristics of digital services. The focus on architecture was useful to gain in-depth knowledge on the aspect so that the knowledge on architecture can later be used to understand business implications on digital services. Our findings provide the following architectural characteristics: i) the architecture of the digital services spans along the layered modular architecture continuum, ii) the application program of the digital services is simultaneously de-coupled and partly coupled with the embedded devices, iii) there exist layers within layer of the digital services, iv) application functionality layer of the digital services is a closed innovation platform. This paper shows the co-existence of architectural characteristic from modular and layered modular architecture. This opens up opportunities for firms to design and redesign digital services during the product life-cycle.

Paper 4: Chowdhury, S. (2014). Expanding business from products to digital services: The value dimensions of digital services enabled by embedded technology, Proceedings of the *Mediterranean Conference on Information Systems (MCIS), Verona, Italy*

After investigating architectural characteristics in paper 3, paper 4 describes the value dimensions of digital services in DPP. This paper shows two value dimensions that are specific to digital services in DPP. The role of this paper in my thesis is that it provides the first empirical account of the relationship between architecture and value creation. Existing research explains three value dimensions. ‘Value-in-exchange’ is traditionally followed by manufacturing firms where they determine monetary value for their products and exchange the value with customers. Recent research argues that 'value-in-exchange' does not emphasize on interacting with customers and value is determined through 'value-in-use' and 'value-in-cocreation'. With the utilization of embedded digital technology in products, new digital services are rendered and new value dimensions are emanating. Existing research informs little about the value dimensions of digital services that result from the combination of digital technology and tangible products. Therefore, in this research, I investigated the value dimensions of digital services. In this paper, along with the three known value dimensions, that is, value-in-exchange, value-in-use and value-in-cocreation, two value dimensions are identified: 'value-in-connectivity' and 'value-in-architecture'. These two value dimensions are specific to digital services in digitalized product platforms.

Paper 5: Chowdhury, S., Åkesson, M., and Thomsen, M. "The Implications of Generativity for Service Innovation in Digitalized Product Platforms" submitted to an international journal

In this paper, the implications of controlling generativity for service innovation in digitalized product platforms are described. The contribution of the paper to the thesis is that it shows the implications of different modes of control, and the relationship and the role of architecture and generativity in value creation. The generativity afforded by digital technology stimulates digital service innovation and radically new business models for manufacturing firms. However, while generativity on the one hand provides opportunities for digital service innovation, on the other hand generativity challenges the traditional transaction logic of manufacturing firms. The previously stable structures and product-centered business in manufacturing industries is de-stabilized and driven towards service orientation. There is a paradoxical relationship between the logic of generative and flexible architecture and the logic of architectural control. In the paper, a conceptual model is proposed to understand this relationship, and illustrate the implications of different modes of control for digital services in digitalized product platforms. In the context of this research, I refer to the control of generativity as restrictions and limitations of the platform flexibility to reduce the possibility of other actors to utilize platform assets and create or produce a new output, structure or process within the digitalized product platform. The findings show that architectural design has profound implications for future business flexibility. The desire to control digital assets can very well hamper desired innovation paths not foreseen when designing the platform. The findings also illustrate that platform assets are potentially disruptive. There are different implications of controlling generativity in different modes. With tight control over generativity, the service logic tends to be firm-centric. With loose control, the logic tends to be customer centric. The balancing of generativity as an enabler of flexibility and the control of generativity is important for manufacturing firms in digitalized product platforms.

The following table (Table 10) presents an overview of the papers.

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Title	A Proposed conceptual framework for identifying the logic of digital services	Challenges and Opportunities related to Remote Diagnostics	Architectural Characteristics of digital services enabled by embedded technology: A Study on Remote Diagnostics Services	Expanding business from products to digital services: value Dimensions of digital services enabled by embedded technology	The Implications of Generativity for Service Innovation in Digitalized Product Platforms
Question	*What is the logic of digital services in relation to traditional notions of service logic and goods logic?*	*What are the business challenges and opportunities related to remote diagnostics?*	*What are the architectural characteristics of digital services enabled by embedded technology?*	*What are the value dimensions of digital services enabled by embedded technology?*	*What are the implications of generativity for service innovation in digitalized product platforms?*
Motivation	The difference between service and products is blurring due to digitalization of products, current IS literature highlights the lack of research on digital services enabled by digitalization	Relative less IS research on understanding business challenges and opportunities of a new technology during the development phase.	The architectural characteristics of digital services resulting from digitalization of products are relatively unexplored in IS	With digitalization of products, new value dimensions are emanating Yet, there is lack of knowledge about the value dimensions of digital services enabled by digitalization.	Digital product platforms are generative. Relatively little is known about the implications of controlling generativity in DPP.
Concepts/ Literature	Goods Logic, Service Logic, Layered modular architecture continuum	IT-enabled resources	Layered architecture of digital technology	Value dimensions of products and services	Generativity, service logic
Contribu-tions	A conceptual framework for identifying the logic of digital services	Business challenges and opportunities of digital services in digitalized product platforms	Architectural characteristics of a digitalized product platform	Value dimensions for digital services in digitalized product platforms	A model of the relationship between generativity, control and flexibility in digitalized product platforms.
Role in the thesis	The paper conceptually shows the relationship between architecture and value	The paper contributes by showing the challenges of building customer relationship and framing a specific logic for services in digitalized product platforms	The paper provides a first empirical account of the architectural aspects which builds the understanding of architecture in digitalized product platforms	The value dimensions highlight the aspects of service logic such as the role of customers, role of firm role of products and determination of value in relation to digital technology.	The paper shows the role of architecture and generativity in value creation by illustrating three modes of control

Table 10: Summary of Research Papers

5.2 Services in Digitalized Product Platforms: Conceptualizing the Underlying Premises

The main contribution of this thesis is a conceptualization of the underlying premises for services in digitalized product platforms. The conceptualization is organized according to three key aspects: value dimensions, architecture and generativity. The following sections present the underlying premises with respect to the three key aspects.

5.2.1 Value Dimensions

Services in digitalized product platforms point at new value dimensions. Digital service innovation in digitalized product platforms requires the combination of platform assets for value creation (Lusch and Nambisan 2015; Yoo et al. 2010a). Value creation in digitalized product platforms is context specific (Lusch and Nambisan 2015). Value-in-context suggests that value is not only always co-created, but also relies on the combination of different assets and thus is contextually specific (Lusch and Vargo 2014). For manufacturing firms, this opens for opportunities to combine assets that previously were not connected in the platform (paper 2). For example, there are opportunities for new value creation afforded by the continuous connection with customers' assets. This was observed in the RDS study when the data generated from sensors embedded in vehicles was combined with vehicle service data owned by customers (paper 3, paper 4). In addition to the existing value dimensions of value-in-exchange, value-in-use and value-in-cocreation, digital service innovation in digitalized product platforms can be described with two specific value dimensions: value-in-architecture and value-in-connectivity (paper 4).

Value-in-architecture

Manufacturing firms face challenges in designing platform assets (paper 2). Established manufacturing firms need to build new digital knowledge on existing knowledge base (Henderson and Clark 1990; Lee and Berente 2012). This challenge was addressed in the RDS study with the vehicular manufacturing firm's creation of new digital knowledge, for example, new architecture, information on vehicle usage and algorithm to predict vehicular faults (paper 3, paper 4, paper 5). In addition, the vehicle manufacturing firm in the study needed to extend the knowledge base regarding their customers to carry out digital service innovation (paper 4). Platform architecture can play a significant role in engaging customers for digital service design (Lusch and Nambisan 2015). To emphasize on customer-centric innovation for value creation (Rai and Sambamurthy 2006), the study of RDS illustrates strategies based on platform assets and architecture to involve customers in designing services (paper 5).

The architecture specifies the assets required for digitalized product platforms. The architecture also specifies the interrelationship between digital and non-digital assets allowing the development of the digitalized product platforms (paper 3). Therefore, the architecture creates a pathway for digitalization of products and designing digital services. Moreover, it is the design of the architecture of digitalized product platforms that provides directions to firms in adding assets to the platforms. The flexibility in the architecture in redesigning digital assets enables the redesign of services (paper 4, paper 5). The redesign of services is particularly important in value creation.

To summarize, the dimension value-in-architecture suggests that service innovation begins with identifying and building platform assets and continues during the product lifecycle through service design and redesign for products.

Value-in-connectivity

In digital service innovation, it is important to involve customers to understand their value perceptions (Jonsson et al. 2008). In the study of RDS, the vehicle manufacturer involved public transport operating companies in the design of the architecture that enabled real-time and continuous connectivity (paper 4 and 5). The connectivity enabled the vehicle manufacturing firm to make new value propositions to customers related to vehicle maintenance and involved them in the design of the services (paper 4, paper 5). The value propositions were connected to the customers' assets. Once customers' assets, in this case digitalized vehicles, were included as parts of the remote diagnostics platform, connectivity with customers was established. The trigger for the digital service innovation was vehicle generated data.

Value-in-connectivity suggests that value creation is dependent on the connectivity and use of customers' assets in digitalized product platforms. As observed in the RDS study, the services were dependent on the connectivity to the customers' vehicles (paper 3, paper 4, paper 5). Value-in-connectivity is related to the time when customers are directly involved with their assets in action. The dimension value-in-architecture related to the identification and building of assets. With a particular focus on value creation and recent argumentation on value-in-context (Barrett et al. 2015; Lusch and Vargo 2014), I propose the following premise:

Premise 1: *In digitalized product platforms, value-in-architecture and value-in-connectivity enable continuous value creation and service innovation opportunities.*

In the RDS study, the collection and analysis of data generated from vehicle usage provided opportunities for the vehicle manufacturing firm to carry out digital service innovation (paper 2). The data was analyzed to evaluate vehicles' health status. The data and the embedded devices in the vehicles contributed to customer-centric innovation (paper 4). The firm was using the devices to have continuous connection with vehicles whereas the vehicle generated data was used as the enabler to design services for the appropriate maintenance of the vehicles. The role of vehicle generated data as a source for value creation was evident as the data was the driver for the continuity of RDS (paper 4, paper 5). The data is an important component in the platform architecture and it is transformed into useful information in the platforms, which opens up opportunities for service innovation (Yoo 2010). Thus, information can play a significant role in value creation (Bharadwaj et al. 2013). The study of RDS illustrates the role of data generated from vehicle usage in a digitalized product platform as a source of service design and value creation (paper 4 and paper 5). The data was used for monitoring and predicting vehicular faults that, in turn, enabled remote diagnostics services. The information derived after analyzing the vehicle data was also the source of new strategies for building customer relationships and service design (paper 5). Based on the above discussion, I propose the following premise:

Premise 2: *In digitalized product platforms, data generated from product usage is a fundamental asset in value creation.*

5.2.2 Architecture

While the embedding of digital technology in modular products is paving the way for layered modular architecture (Henfridsson et al. 2014; Yoo et al. 2010a), a key question arises with regard to the role of the architecture in digital service innovation (Barrett et al. 2015). In the RDS study, significant attention was paid to understand the architectural aspects of the remote diagnostics platform (Paper 1, Paper 3, Paper 4, Paper 5).

Digital service innovation is enabled by an architecture combining physical modules and the layers of digital technology (Barrett et al. 2015; Yoo et al. 2010a). The source of value creation emerges from the architecture in digitalized product platforms (Yoo et al. 2010a). In the study of RDS, the combination of digital and physical assets created new architectural characteristics and shaped the role of digital assets in value creation (paper 3, paper 4). The study shows that the architecture creates opportunities for new value propositions and redesign of services (paper 4 and paper 5). The partial coupling and decoupling of digital assets with vehicles enabled the redesign of RDS as different operations can be performed on vehicle generated data. The opportunities for the redesign enabled continuous involvement of customers in value creation (paper 4, paper 5).

Leveraging the emergent value of the architecture of digitalized product platforms requires specific architectural knowledge (Svahn et al. 2009). Building architectural knowledge is particularly challenging for manufacturing firms because of the need to understand the use context (Andersson et al. 2008). The study on RDS illustrates a challenge related to the contents layer of the architecture. For example, it was necessary to receive vehicle generated data to serve the customer's vehicles with monitoring and diagnostics of vehicle status. Real-time connection to vehicles was established as the connectivity was essential to receive the data for enabling services (paper 4).

There is a high dependency on vehicle generated data and stable wireless transmission for enabling RDS. In case of any anomaly, for example, if data was not received, the RDS could not be provided. Similarly, there was a dependency between the algorithm at the back-office and the embedded devices in the vehicles (paper 3). Two platform assets, the algorithm and vehicle generated data, had characteristics similar to layered modular architecture because they were product agnostics (Yoo et al. 2010a). On the contrary, the platform assets, i.e, embedded devices had characteristics similar to modular architecture. However, the algorithm and the data were highly dependent on embedded devices in the vehicles. The algorithm is particularly designed to analyze the data. Moreover, a part of the algorithm functions inside the embedded devices. In that sense, the algorithm is also dependent on the devices (paper 3). In this way, a mutual dependence was established between the platform assets in the architecture. This mutual dependency was a source for value creation, one asset in the architecture could not be used without the other. The mutual dependency is an example of how different architectural frames interplay when physical and digital modules are combined (Henfridsson et al. 2014). Architectural design can have influence on the modules of platform assets and the influence can vary in different platforms (Tiwana et al. 2010). The study of RDS shows the mutual dependence between the modules of platform assets. I therefore propose the following premise:

Premise 3: *In digitalized product platforms, the mutual dependence between modular assets and layered modular assets enables value creation.*

5.2.3 Generativity

The embedding of digital technology in physical products makes digitalized products generative (Yoo 2010). Digitalized products are not simple digital objects; rather they function as enablers for digital services in relation to products (Andersson et al. 2008; Henfridsson et al 2014). In digitalized product platforms, the products function as digital assets for computation and data generation. The data generated from the products is, as described above, a valuable platform asset as the data can be used for designing services for customers (Jonsson et al. 2008).

In the RDS study, data generated from the usage of digitalized products was regarded as a crucial platform asset in enabling digital service innovation (paper 4, paper 5). The exploration of the role of customers in relation to product generated data was a way to strategize customer involvement in value co-creation (paper 5). As described above, besides the product generated data, capacity of two other digital assets, the embedded devices and algorithm, were essential to the platform (paper 3, paper 5).

The observations from the study of RDS show that generativity in the platform was controlled by the vehicle manufacturing firm SmartBus. The architectural design of the platform allowed the firm to control the embedded devices, the data and the algorithm (paper 3, paper 5). Customers were not allowed access to the data and the algorithm. As the customer involvement in the service design was more as idea generators, the role of customers was limited in service design. Control of platform assets needs to be strategized to create value from the platform generativity (Eaton et al. 2015; Yoo et al. 2012). As observed in the RDS study, the vehicle manufacturing firm strategized customer relationships in service design. The strategies included different degrees of control over digital assets and customers (paper 5). I therefore propose the following premise for services based on the above discussion:

Premise 4: *In digitalized product platforms, platform generativity is configured for value co-creation with customers.*

The study of RDS in this research empirically illustrates generativity in the context of the vehicle industry. Additional digital services can be designed and included with the existing digital services (Lee and Berente 2012). Leveraging the generativity in the remote diagnostics platform benefited public transport operating companies because digital platform assets were deployed to reduce breakdowns of vehicles (paper 4, paper 5). Due to the generativity afforded by digitalization, digitalized product platforms are never fully complete, that they have many uses yet to be conceived of (Tilson et al. 2010; Zittrain 2008). For example, the algorithm in the RDS study was continuously re-programmed to obtain better results for fault diagnostics (paper 4). The re-programmability of the algorithm enables re-evaluating value propositions, which have implications for further value creation. The premise below is proposed in light of this discussion:

Premise 5: *In digitalized product platforms, platform generativity enables continuous re-evaluation of value propositions.*

5.3 Summarizing the Premises

On the basis of three key aspects, value dimensions, architecture and generativity, the underlying premises for services in digitalized product platforms are proposed. The premises are summarized in Table 11.

	Premise	**Explanation and Comments**
P1	In digitalized product platforms, value-in-architecture and value-in-connectivity enable continuous value creation and service innovation opportunities	The architecture of digitalized product platforms and connectivity to digitalized products enable firms in designing and redesigning services related to digitalized products.
P2	In digitalized product platforms, data generated from product usage is a fundamental asset in value creation	Product generated data is the fundamental driver of continuous digital service innovation and value creation
P3	In digitalized product platforms, the mutual dependence between modular assets and layered modular assets enables value creation.	Value creation is enabled by the simultaneous use of the platform assets with modular architecture and the assets with layered modular architecture.
P4	In digitalized product platforms, platform generativity is configured for value co-creation with customers.	Firms can strategize access of platform assets to customers to design services according to customer needs
P5	In digitalized product platforms, platform generativity enables continuous re-evaluation of value propositions.	As digital assets are re-programmable, firms can redesign the existing services and make new value propositions with new services

Table 11: Underlying premises for services in digitalized product platforms

The premises provide a ground for understanding services in digitalized product platforms in relation to value dimensions, architecture and generativity. The premises are based on five concepts in relation to services in digitalized product platforms: value-in-architecture, value-in-connectivity, fundamental asset for value creation, mutual dependence of modular and layered modular assets, and re-evaluation of value propositions. Value-in-architecture and value-in-connectivity are applicable for a class of digital services, services enabled by the usage of specific digitalized products. Data generated from product usage has been identified as the fundamental asset for enabling value creation. The continuity of services depends on the product usage data. The connectivity to products is the stepping stone for building customer relationship.

In digitalized product platforms, the assets do not work independently from each other. Rather, there is mutual dependence. The platforms consist of modular and layered modular assets. In the platforms, there exists a complex combination of physical non-digital assets and digital assets. The design of the platform architecture enables the intertwined activities of digital and physical assets. The mutual dependency as the dependency is used for controlling both modular and layered modular assets.

As digital technology is generative, the digital assets play a significant role in digital service innovation. The digital assets can be leveraged to perform complex tasks. Platform generativity creates digital service innovation opportunities by establishing a loop of re-evaluating their value propositions as the digital assets are re-programmable, transferrable, and most importantly controllable to different degrees.

5.4 Theoretical Implications

This thesis aims to contribute to the literature on digital innovation as well as the literature on services in IS by presenting the underlying premises for services in digitalized product platforms. The premises are concerned with value creation and value dimensions in relation to architecture and generativity. The premises include concepts specific for services in digitalized product platforms. The concepts are: value-in-architecture, value-in-connectivity, mutual dependence of platform assets, generativity of product generated data, re-evaluation of value propositions. The premises frame the service logic in digitalized product platforms and contribute to the literature on digital innovation (see e.g. Henfridsson et al. 2014; Tilson et al. 2010; Yoo et al. 2010a) and service aspect of IS (see e.g. Bardhan et al. 2010; Rai and Sambamurthy 2006; Lusch and Nambisan 2015).

The example of digitalized vehicles illustrates technology-embeddedness. Although technology-embeddedness is growing in business (Jonsson et al. 2008), less knowledge is available on value creation in technology-embedded situations (Nambisan 2013; Kohli and Grover 2008). This thesis addresses the knowledge gap and presents two specific value dimensions of services in digitalized product platforms. Novel combinations of assets for value creation can be envisioned through digital technology (Sambamurthy and Zmud 2000). The value dimensions present a way for value creation using different digital and non-digital assets in the digitalization era. The conceptualization of the value dimensions (Premise 1) is useful as not recognizing the dimensions would provide a limited view of service innovation in digitalized product platforms.

This thesis empirically illustrates the role of information in value creation of services in digitalized product platforms (Premise 2). The illustration contributes to the inquiry into the role of information as a source of value creation in digitalization (Bharadwaj et al. 2013). A rich insight on product usage data is useful as digitalized products are sources of digital data that are waiting to be leveraged. Leveraging data with customers can create opportunities for customer-centric innovation. While designing digital services, gaining knowledge on value creation for customers with customer-centric innovation is an important endeavor for IS research (Rai and Sambamurthy 2006). Customer-centric innovation is important to understand the perceptions of the customers (Jonsson et al. 2008). While applying the concept of service-dominant logic from marketing (Vargo and Lusch 2004), this thesis examined value creation in digitalization which is required to be addressed in IS research incorporating important concepts and constructs from other business disciplines (Nambisan 2013).

This research shows the identification and combination of assets in making value propositions and in value creation. With growing instances of digitalized platforms (Lusch and Nambisan 2015; Yoo et al 2010a), insights about the role of platform architecture and assets in making value propositions and in value creation is significant. This thesis offers new insights into the implications of architecture in digital service innovation. The interplay between different architectural frames is required to be investigated (Henfridsson et al. 2014). The interplay is addressed by illustrating the implications of combining digital layers in modular product architecture (Premise 1, Premise 3, Premise 4, Premise 5). The focus of previous literature is commonly on mobile platforms (see e.g. Eaton et al. 2015; Tiwana et al. 2010; Ghazawneh and Henfridsson 2013). The premises of this thesis expand the inquiry in IS of digital platforms in relation to digitalized product platforms and a specific class of services where a high dependency exists between the product usage data and value creation.

With the investigation of architectural characteristics of RDS, this research contributes to the ongoing discussion of the emergence of layered modular architecture that specifies the combination of physical modules with digital layers (Kallinikos et al. 2013; Lusch and Nambisan 2015; Yoo et al. 2010a). While more and more modular products are getting digitalized and layered modular architectures are emerging, the technical and strategic dimensions of digitalization is an important research avenue for IS (Yoo et al. 2010a). The description of architectural characteristics and specific value dimensions of digital services contribute to the discussion of technical and strategic dimensions (Premise 1, Premise 3, Premise 4, Premise 5).

Digitalization has brought changes in the economy and at the core of these changes in digitally enabled generativity (Yoo 2013). Investigation on leveraging the generativity of digital technology has gained recent interest (see e.g. Svahn et al. 2015). Although generativity has gained attention, studies of the potential and capacity of the digital data in service innovation still awaits research (Kallinikos et al. 2013). New insights are required that can guide firms to leverage generativity while shifting emphasis from modularity (Yoo 2013). This research highlights the possible outcome of leveraging generativity in digitalized product platforms (Premise 4, Premise 5). Special attention has been paid to investigate the capacity of the data generated from the usage of digitalized product. The role of algorithms has recently gained attention in IS research and much future research has been called for (Orlikowski and Scott 2015). This thesis contributes with depicting the role of an algorithm in digitalized product platforms in re-evaluating value propositions (Premise 5).

While presenting the role of architecture and generativity in value creation in digitalized product platforms, this thesis contributes to the platform discussion (see e.g. Gawer 2014; Thomas et al. 2014). Various strategic actions can have implications in digital platforms (Woodard et al. 2013). A strategy is required to trigger platform assets for digital service innovation (Lusch and Nambisan 2015). The thesis suggests different strategic uses of digital assets for triggering digital service innovation. Strategic control of generative digital platforms has been given importance in IS research (see e.g. Tilson et al. 2010; Yoo et al. 2010a). Control plays a significant role as no control over platform assets may create varied and fragmented platforms, which makes it difficult for firms to leverage value from innovation (Yoo et al. 2012). The earlier studies on platform control were focusing on control of mobile or web-based platforms and with less emphasis on controlling product generated data (see e.g. Eaton et al. 2015, Ghazawneh and Henfridsson 2013; Henfridsson and Bygstad 2013). This thesis adds to the knowledge by presenting strategies for controlling access to digital assets (Premise 4).

6. Concluding Remarks

The aim of this thesis is to answer the research question: *what are the underlying premises for services in digitalized product platforms?* The premises for services in digitalized product platforms are intended to highlight key aspects of digital service innovation. The key aspects were value dimensions, architecture, and generativity. The conceptualization of the underlying premises for services in digitalized product platforms provides new insights on digital service innovation research that have implications for practice and future research.

6.1 Practical Implications

A practical implication of this thesis relates to the role of data generated from product usage. One of the premises of this study showed that product generated data is the fundamental asset in value creation. Awareness of the role of product usage data in value creation is important for manufacturing firms in strategizing service design. The premises can guide in decision making in platform architecture design. The premises can also be useful for increasing flexibility of the architecture. The premises on generativity point at strategizing for co-designing services with customers even if the platform assets are controlled by firms. Firms can employ the mutual dependence of platform assets in designing services. As long as the architectural design ensures the mutual dependency of digital and non-digital assets, the assets will be facilitating service design. This mutual dependence not only enables firms to design more digital services for customers' assets, but also creates opportunities for customers in designing services.

6.2 Limitations and Future Research

The context of the thesis is within the vehicle industry. The context set a limitation for the research. Future research is required to investigate services in other digitalized product platforms. The premises presented here can be applied in other research context to investigate the value dimensions, architecture and generativity. Future research can inform about the implications of value-in-architecture and value-in-connectivity in value creation in other settings, such as healthcare industry where the use of digitalized equipment is common. Another limitation of this research is in its conceptualization of generativity. The premises of the research conceptualize generativity at strategic level. A future research agenda will be to implement the strategies presented in the thesis in a digitalized product platform. Particularly, it will be interesting to apply the premises on generativity in digitalized consumer products to observe how platform assets can be configured to create value. Moreover, the role of platform assets in value propositions can also be investigated in the context of digitalized consumer products. The premise on product usage data presents it as the fundamental asset in value creation. More research is required to gain deeper understanding on product usage data. The premises are presented based on a research where technology is in the development phase. Research on a matured technology would shed a new light on the applicability of the premises.

7. References

Adomavicious, G., J. C. Bockstedt, A. Gupta, R. J. Kauffman. (2008). “Making sense of technology trends in the information technology landscape: A design science approach”. *MIS Quarterly* 32(4): 779–809.

Alter, S. (2010). "Viewing Systems as Services: A Fresh Approach in the IS Field", *Communications of the Association for Information Systems* 26: 195-214

Alter, S. (2012). "Challenges for service science." *Journal of Information Technology Theory and Application* 13(2): 22-38.

Amit, R. and Zott, C. (2001). "Value creation in e-business." *Strategic management journal* 22(6-7): 493-520.

Andersson, M. and R. Lindgren (2005). "The mobile-stationary divide in ubiquitous computing environments: lessons from the transport industry." *Information systems management* 22(4): 65-79

Andersson, M., Lindgren, R. and Henfridsson, O. (2008). "Architectural knowledge in inter-organizational IT innovation." *The Journal of Strategic Information Systems* 17(1): 19-38.

Babinksy, H. (2003) How do wings work? Physics Education, 38 (6): 497–503

Baldwin, C. Y. and K. B. Clark (2000). *Design rules: The power of modularity,* MIT Press.

Baldwin, C. Y and Woodard, C. J. (2009). The Architecture of Platforms: A unified view. In: Gawer, A. (ed) *Platforms, Markets and Innovation*, Edward Elgar, Massachusetts, 19-44

Bardhan, I. R., Demirkan, H., Kannan, P., Kauffman, R.J., and Sougstad, R. (2010). "An interdisciplinary perspective on IT services management and service science." *Journal of Management Information Systems*, 26(4): 13-64.

Barras, R. (1986). "Towards a theory of innovation in services." *Research policy* 15(4): 161-173.

Barrett, M., Davidson, E., Prabhu, J. and Vargo, S. L. (2015). "Service Innovation in the Digital Age: Key Contributions and Future Directions", *MIS Quarterly* 39(1): 135-154.

Benbasat, I., D. K. Goldstein and M. Mead (1987). "The case research strategy in studies of information systems." *MIS quarterly, 11(3):*369-386.

Bergvall-Kåreborn, B. and D. Howcroft (2013). "‘The future’s bright, the future’s mobile’: a study of Apple and Google mobile application developers." *Work, Employment & Society, 1-18*

Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*, Yale University Press.

Bettencourt, L. A. and A. W. Ulwick (2008). "The customer-centered innovation map." *Harvard Business Review* 86(5): 109-114.

Biehl, M., Prater, E., and McIntyre, J. R. (2004). Remote repair, diagnostics and maintenance. *Communication of the ACM*, 47(11): 101-106.

Bharadwaj, A. S. (2000). "A resource-based perspective on information technology capability and firm performance: an empirical investigation." *MIS Quarterly,* 169-196.

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., and Venkatraman, N. (2013). "Digital business strategy: toward a next generation of insights." *MIS Quarterly* 37(2): 471-482.

Bitner, M. J., Ostrom, A.L., and Morgan, F. N. (2008). "Service blueprinting: a practical technique for service innovation." *California management review* 50(3): 66.

Borden, N.H. (1964). “The concept of the marketing mix”, *Journal of Advertising Research*, (4): 2-7

Bouvard, K., S. Artus, C. Berenguer and V. Cocquempot (2011). "Condition-based dynamic maintenance operations planning and grouping. Application to commercial heavy vehicles." *Reliability Engineering and System Safety* 96(6): 601-610.

Braun, V. and Clarke, V. (2006). "Using thematic analysis in psychology." *Qualitative research in psychology* 3(2): 77-101.

Carlo, J. L., Lyytinen, K., and Rose, G.M. (2011). "Internet computing as a disruptive information

technology innovation: the role of strong order effects1." Information systems journal 21(1): 91-122.
Chiasson, M. W. and E. Davidson (2005). "Taking industry seriously in information systems research." *MIS Quarterly*, 29(4): 591-605.
Constantiou, I. D., C. Lehrer and T. Hess (2014). "Changing information retrieval behaviours: an empirical investigation of users' cognitive processes in the choice of location-based services." *European Journal of Information Systems* 23(5): 513-528.
Coombs, R. and Miles, I. (2000). Innovation, measurement and services: the new problematique. *Innovation systems in the service economy*, Springer: 85-103.
*den Hertog, P. (2000). "*Knowledge-intensive business services as co-producers of innovation*" International Journal of Innovation Management 4(4): 491-528.*
Dennis, A. R. and M. J. Garfield (2003). "The adoption and use of GSS in project teams: Toward more participative processes and outcomes." *MIS Quarterly*, 27(2): 289-323.
Drejer, I. (2004). "Identifying innovation in surveys of services: a Schumpeterian perspective." *Research policy* 33(3): 551-562.
Droege, H., Hildebrand, D., and Heras Forcada, M. A. (2009). "Innovation in services: present findings, and future pathways." *Journal of Service Management* 20(2): 131-155.
Eaton, B., S. Elaluf-Calderwood, C. Sørensen and Y.Yoo (2011). Dynamic structures of control and generativity in digital ecosystem service innovation: the cases of the Apple and Google mobile app stores, London School of Economics and Political Science.
Eaton, B. D. (2012). The dynamics of digital platform innovation: Unfolding the paradox of control and generativity in Apple's iOS, Doctoral Thesis, London School of Economics.
Eaton, B., Elaluf-Calderwood, S., Sørensen, C. and Yoo, Y. (2015). "Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System." *MIS Quarterly* 39(1): 217-243.
EUCAR. (2012). Automotive research and innovation: Towards the horizon. Retrieved December 7, 2012, from http://www.eucar.be/publications/ EUCAR
Gao, L. S. and Iyer. B. (2006). Analyzing complementarities using software stacks for software industry acquisitions. *Journal of Management Information Systems* 23(2):119–147.
Garud, R., and Kumaraswamy, A. (1995). Technological and organizational designs for realizing economies of substitution. *Strategic Management Journal*, 16: 93-109.
Gawer, A. (2009). Platform dynamics and strategies: from products to services. In: Gawer, A. (ed) *Platforms, Markets and Innovation*, Edward Elgar, Massachusetts, pp. 45-76
Gawer, A. (2014). "Bridging differing perspectives on technological platforms: Toward an integrative framework." *Research Policy* 43(7): 1239-1249.
Gawer, A. and M. A. Cusumano (2014). "Industry platforms and ecosystem innovation." *Journal of Product Innovation Management,* 31(3): 417-433.
Ghazawneh, A. and O. Henfridsson (2013). "Balancing platform control and external contribution in third-party development: the boundary resources model." *Information Systems Journal* 23(2): 173-192.
Gillespie, T. (2010). "The politics of 'platforms" *New Media and Society* 12(3): 347-364.
Grover, V. and Kohli, R. (2012). "Cocreating IT Value: New Capabilities and Metrics for Multifirm Environments." MIS Quarterly, 36(1): 225-232.
Grönroos, C. (1996). Relationship Marketing Logic, *The Asia-Australia Marketing Journal*, 4(1): 7-18
Grönroos, C. (2006). "Adopting a Service Logic for Marketing", *Marketing Thoery*, 6(3) :317-333.
*Henderson, R. M. and Clark, K. B (1990). "*Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms*" Administrative science quarterly, 35(1):9-30.*

Henfridsson, O., Lindgren, R. (2005). "Multi-Contextuality in Ubiquitous Computing: Investigating the Car Case through Action Research," *Information and Organization* (15:2):95-124.
Henfridsson, O. and Bygstad, B. (2013). "The generative mechanisms of digital infrastructure evolution" *MIS Quarterly* 37(3): 907-931.
Henfridsson, O., L. Mathiassen and F. Svahn (2009) Reconfiguring Modularity: Closing Capability Gaps

In Digital Innovation, *Sprouts: Working Papers on Information Systems 9(22),* Association for Information Systems.
Henfridsson, O., Mathiassen, L., and Svahn, F. (2014). "Managing technological change in the digital age: the role of architectural frames." *Journal of Information Technology*, 1-14
Holmström, H. (2004). *Community based customer involvement for improving packaged software development*, Doctoral Dissertation, University of Gothenburg, Sweden
Hylving, L., O. Henfridsson and L. Selander (2012). "The Role of Dominant Design in a Product Developing Firm's Digital Innovation." *Journal of Information Technology Theory and Application* 13(2): 6-21
Hylving, L. and Schultze, U. (2013). "Evolving the Modular Layered Architecture in Digital Innovation: The Case of the Car's Instrument Cluster." *Proceedings of ICIS*
Jarvenpaa, S. L. and D. E. Leidner (1998). "An information company in Mexico: Extending the resource-based view of the firm to a developing country context." *Information Systems Research* 9(4): 342-361.
Jelassi, T. (1993). "Gaining business from information technology: the case of Otis Elevator, France." *European Management Journal* 11(1): 62-73.
Jonsson, K., Westergren, U. H and Holmström, J. (2008). "Technologies for value creation: an exploration of remote diagnostics systems in the manufacturing industry." *Information Systems Journal* 18(3):227-245.
Jonsson, K., J. Holmström and K. Lyytinen (2009). "Turn to the material: Remote diagnostics systems and new forms of boundary-spanning." *Information and organization* 19(4): 233-252.
Jonsson, K. (2010). *Digitalized industrial equipment: An investigation of remote diagnostics services*, Doctoral Thesis, Umeå University, Sweden
Kallinikos, J., Aaltonen, A. and Marton, A. (2013). "The ambivalent ontology of digital artifacts." *MIS Quarterly* 37(2): 357-370.
Kaplan, B. and J. A. Maxwell (2005). "Qualitative research methods for evaluating computer information systems." *Evaluating the Organizational Impact of Healthcare Information Systems*. 30-55.
Klein, H. K., and Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly, 23*(1): 67-93.
Kohli, R. and Grover, V. 2008. "Business Value of IT: An Essay on Expanding Research Directions to Keep up with the Times." *Journal of the association for information systems* 9(1), pp. 23-39
Kotler, P. and Keller, K.L. (2006). *Marketing Management*, 12th Edition, NJ: Pearson Prentice Hall
Kowalkowski, C. (2010). "What does a service-dominant logic really mean for manufacturing firms?" *CIRP Journal of Manufacturing Science and Technology* 3(4): 285-292.
Kuschel, J. and Dahlbom, B. (2007). Mobile Services for Vehicles. In the *Proceedings of ECIS*.
Kuschel, J. (2009). *Vehicle Services*, PhD thesis, University of Gothenburg, Sweden
Lee, J. and N. Berente (2012). "Digital Innovation and the Division of Innovative Labor: Digital Controls in the Automotive Industry." *Organization Science* 23(5): 1428-1447.
Lindgren, R., Andersson, M., and Henfridsson, O. (2008). Multi-contextuality in boundary-spanning practices. *Information Systems Journal*, 18(6): 641-661.
Lucas, H. C. and J. M. Goh (2009). "Disruptive technology: How Kodak missed the digital photography revolution." *The Journal of Strategic Information Systems* 18(1): 46-55.
Lusch, R. F. and Nambisan, S. (2015). "Service Innovation: A Service-dominant logic perspective", *MIS Quarterly, 39(1): 155-175*
Lusch, R. F. and S. L. Vargo (2014). *Service-dominant logic: Premises, perspectives, possibilities*, Cambridge University Press.
Lyytinen, K. and Yoo, Y. (2002). "Research commentary: the next wave of nomadic computing." *Information systems research* 13(4): 377-388.
Lyytinen, K. and Rose, G. M. (2003). "The disruptive nature of information technology innovations:

the case of internet computing in systems development organizations." *MIS quarterly*, 557-596.
Maas, S., Herb, S., and Hartmann, E. (2014). "Supply chain services from a service-dominant perspective: a content analysis." International Journal of Physical Distribution and Logistics Management 44(1/2): 58-79.
Maxwell, J. (1997). Designing a qualitative study. In Bickman, L. and Rog, D. J. (Eds.) *Handbook of applied social research methods* (pp. 69-100). Thousand Oaks, CA: Sage.
Maxwell, J. A. (2005). *Qualitative research design: An interactive approach*, Sage Publications
Meyer, M. H. and Lehnerd, A. P. (1997). *The power of product platforms*, Simon and Schuster.
Meyer, M. H. and D. Dalal (2002). "Managing platform architectures and manufacturing processes for nonassembled products." Journal of product innovation management 19(4): 277-293.
Miles, M. B. and A. M. Huberman (1994), *Qualitative data analysis: An expanded sourcebook*, Sage Publications,
Miles, I. (2012). Introduction to service innovation. Case studies in service innovation, Springer: 1-15.
Myers, M. D. (1997). "Qualitative research in information systems." *MIS Quarterly* (21:2)
Myers, M. D. and Newman, M. (2007). The Qualitative Interview in IS research: Examining the craft, *Information and Management*, 17, 2-26
Nambisan, S. (2013). "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research." *Journal of the Association for Information Systems* 14(4).
Nandhakumar, J. and Jones, M. (1997). "Too close for comfort? Distance and engagement in interpretive information systems research." *Information Systems Journal*, 7(2): 109-131.
Nobeoka, K. and M. A. Cusumano (1997). "Multiproject strategy and sales growth: the benefits of rapid design transfer in new product development." Strategic Management Journal 18(3): 169-186.
Orlikowski, W. J. and J. J. Baroudi (1991). "Studying information technology in organizations: Research approaches and assumptions." *Information systems research* 2(1): 1-28.
Orlikowski, W. and S. V. Scott (2015). "The Algorithm and the crowd: Considering the materiality of service innovation.", *MIS Quarterly*, 39 (1), 201-216
Perreault, W. D. and McCarthy, E. J. (2002). *Basic marketing: A global-managerial approach*, McGraw Hill: Irwin
Rai, A. and Sambamurthy, V. (2006). "The growth of interest in services management: Opportunities for information systems scholars." Information Systems Research 17(4): 327-331.
Remneland-Wikhamn, B., J. Ljungberg, M. Bergquist and J. Kuschel (2011). "Open innovation, generativity and the supplier as peer: The case of iphone and android." *International Journal of Innovation Management* 15(1): 205-230.
Robertson, D. and K. Ulrich (1998). "Planning for product platforms." *Sloan management review* 39(4):19:31
Sambamurthy, V. and Zmud, R. W. (2000). "Research commentary: The organizing logic for an enterprise's IT activities in the digital era—A prognosis of practice and a call for research." Information systems Research, 11(2): 105-114.
Sandberg, J. (2014). *Digital Capability: Investigating Coevolution of IT and Business Strategies*, Doctoral Thesis, Umeå University, Sweden
Scupola, A. (2011). *Developing Technologies in E-services, Self-services, and Mobile Communication: New Concepts*, Information Science Reference.
Schilling, M. A. (2000). "Toward a general modular systems theory and its application to interfirm product modularity." Academy of management review 25(2): 312-334.
Shaw, G., A. Bailey and A. Williams (2011). "Aspects of service-dominant logic and its implications for tourism management: Examples from the hotel industry." *Tourism Management* 32(2): 207-214.
Simmons, D. (2001). *Field service management: A classification scheme and study of server flexibility*. Binghamton University, New York.
Sirilli, G. and Evangelista, R (1998). "Technological innovation in services and manufacturing: results from Italian surveys." Research policy 27(9): 881-899.

Slywotzky, A. and R. Wise (2003). "Demand innovation: GM's OnStar case." *Strategy and Leadership* 31(4): 17-22.

Svahn, F., Henfridsson, O., and Yoo, Y. (2009). "A threesome dance of agency: Mangling the sociomateriality of technological regimes in digital innovation." *Proceedings of ICIS*

Svahn, F. (2012). "Digital Product Innovation: Building Generative Capability through Architectural Frames." Doctoral Dissertation, Umeå University

Svahn, F., R. Lindgren and L. Mathiassen (2015). Applying Options Thinking to Shape Generativity in Digital Innovation: An Action Research into Connected Cars. Hawaii International Conference on System Sciences (HICSS) .

Thomas, L. D., E. Autio and D. M. Gann (2014). "Architectural leverage: putting platforms in context." *The Academy of Management Perspectives* 28(2): 198-219.

Tilson, D., Lyytinen, K., and Sørensen, C. (2010). "Research Commentary—Digital Infrastructures: The Missing IS Research Agenda." *Information Systems Research* 21(4): 748-759.

Tilson, D., Sorensen, C. and Lyytinen, K. (2012). Change and control paradoxes in mobile infrastructure innovation: the Android and iOS mobile operating systems cases. 45th Hawaii International Conference on System Science

Tilson, D., C. Sorensen and K. Lyytinen (2013). Platform Complexity: Lessons from the music industry. System Sciences, *46th Hawaii International Conference on Systems Science*, IEEE.

Tiwana, A., B. Konsynski and A. A. Bush (2010). "Research commentary-Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics." *Information Systems Research* 21(4): 675-687.

Tripsas, M. (2009). "Technology, identity, and inertia through the lens of "The Digital Photography Company"." *Organization Science* 20(2): 441-460.

Ulrich, K. (1995). "The role of product architecture in the manufacturing firm." *Research policy* 24(3): 419-440.

Utterback, J. M. and W. J. Abernathy (1975). "A dynamic model of process and product innovation." *Omega* 3(6): 639-656.

Vargo, S.L. and Lusch, R.F. (2004). "Evolving to a New Dominant Logic of Marketing", *Journal of Marketing*, 68(1):1-17.

Vargo, S. L., Maglio, P. P and Akaka, M. A. (2008). "On value and value co-creation: A service systems and service logic perspective." *European management journal* 26(3): 145-152.

Vargo, S. L. and Lusch, R. F. (2008). "From goods to service (s): Divergences and convergences of logics." Industrial Marketing Management 37(3): 254-259.

VINNOVA. (2012). Guidad integrerad fjärr- och verkstadsdiagnos. Retrieved December 7, 2012, from http://www.vinnova.se/sv/Resultat/Projekt/Effekta/ Guidad-integrerad-fjarr--och-verkstadsdiagnos/

Williams, K., Chatterjee, S., and M. Rossi (2008). "Design of emerging digital services: a taxonomy." *European Journal of Information Systems* 17(5): 505-517.

Walsham, G. (1993). Interpreting information systems in organizations. Chichester: Wiley.

Walsham, G. (1995). "Interpretive case studies in IS research: nature and method." European Journal of Information systems 4(2): 74-81.

Walsham, G. (2006). "Doing interpretive research." *European journal of information systems* 15(3): 320-330.

Wang, H. (2002). "A survey of maintenance policies of deteriorating systems." *European journal of operational research* 139(3): 469-489.

Woodard, C. J., N. Ramasubbu, F. T. Tschang and V. Sambamurthy (2013). "Design Capital and Design Moves: The Logic of Digital Business Strategy." *MIS Quarterly*, 37(2): 537-564

Yoo (2010). "Computing in everyday life: A Call For Research on Experiential Computing", *MIS Quarterly*, 34(2):213-231

Yoo, Y., Henfridsson, O. and Lyytinen, K. (2010a). "Research Commentary - The new organizing logic of Digital Innovation: An Agenda for Information Systems Research". *Information Systems*

Research, 21(4): 724-735
Yoo, Y., K. Lyytinen, V. Thummadi and A. Weiss (2010b). Unbounded innovation with digitalization: A case of digital camera. Annual Meeting of the Academy of Management.
Yoo, Y., R. J. Boland Jr, K. Lyytinen and A. Majchrzak (2012). "Organizing for innovation in the digitized world." *Organization Science* 23(5): 1398-1408.
Yoo, Y. (2013). "The Tables Have Turned: How Can the Information Systems Field Contribute to Technology and Innovation Management Research?" *Journal of the Association for Information Systems* 14(5): 227-236.
You, S., Krage, M. and Jalics, L. (2005). Overview of remote diagnosis and maintenance for automotive systems, *SAE World Congress*, Detroit.
Zhao,X., Qian, T., Mei, G., Kwan, C., Zane, R., Walsh, C., Paing, T., Popovic, Z. (2007) "Active Health monitoring of an aircraft wing with an embedded piezoelectric sensor/actuator network," *Smart Materials and Structures*, 16:1218-1225
Zittrain, J. L. (2006). "The generative internet." *Harvard Law Review*: 1974-2040.
Zittrain, J. L. (2008). The future of the Internet and how to stop it, Yale University Press*.*
Åkesson, M. (2009). *Digital Innovation in the value networks of newspapers*, PhD thesis, University of Gothenburg

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