Design of a Reference Model for Smart Services

Masterarbeit

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„Die künftige Stärke
moderner Industrieunternehmen wird
nicht zuletzt durch
die Innovationskraft
im Servicebereich entschieden.“[1]

Prof. Dr. Dr. h. c. mult.
Wolfgang A. Herrmann

[1] Cf. Reichwald et al. (2008), p. 2.

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1. Introduction

1.1. Motivation and Relevance

Remaining competitive on a fast growing market challenges companies from all sectors. Thus, the application of innovative technologies that have arisen with the fourth industrial revolution is vital. Industry 4.0 is the driving motor for the digitization and automation of products, processes and services that are interconnected through the internet, exchange information and enable a fusion of the physical and virtual world through cyber-physical systems (CPS). Companies have to cooperate beyond boundaries of sectors and have to adapt and extent their product and service portfolios consistently (Kagermann et al., 2014, p.18). At this point innovative data-based Smart Services that can optimize various processes come into focus. The power of Smart Services can be observed on the retail market, but more and more traditional industries like the automotive, machinery, chemical, logistics and energy industry profit from them.

Over the past 20 years manufacturing companies have developed into more service-oriented businesses as the conventional business models depending on mainly high-quality products and after-sales service have underwent extreme competition. Outdated value chains evolve into value networks as new service systems incorporate IT providers, manufacturers and customers among many other participants of the value creation network. Hence, many solution providers have focused on creating new innovative value adding service products that support manufacturing companies to distinguish themselves from competitors. Putting a focus on services immensely improves their market position and revenues (Peters et al., 2016, pp.137ff). Vargo and Lush (2008) talk about a change from a goods-dominant logic (GDL) to a service-dominant logic (SDL) in the manufacturing industries over the last two decades.

According to a recent study, Germany's leading industries are well-developed in terms of digitization in comparison to their global competitors. Figure 1 shows the rankings of Germany's level of digitization compared to the top three countries of the individual sectors with the ranking 1 for "highly digitized" and 4 for "not digitized at all". Especially in the mechanical engineering, automotive and logistics sector, Germany is far more digitized than its competitors, Sweden, Switzerland, the USA and the UK (Kagermann et al., 2015, p.35).

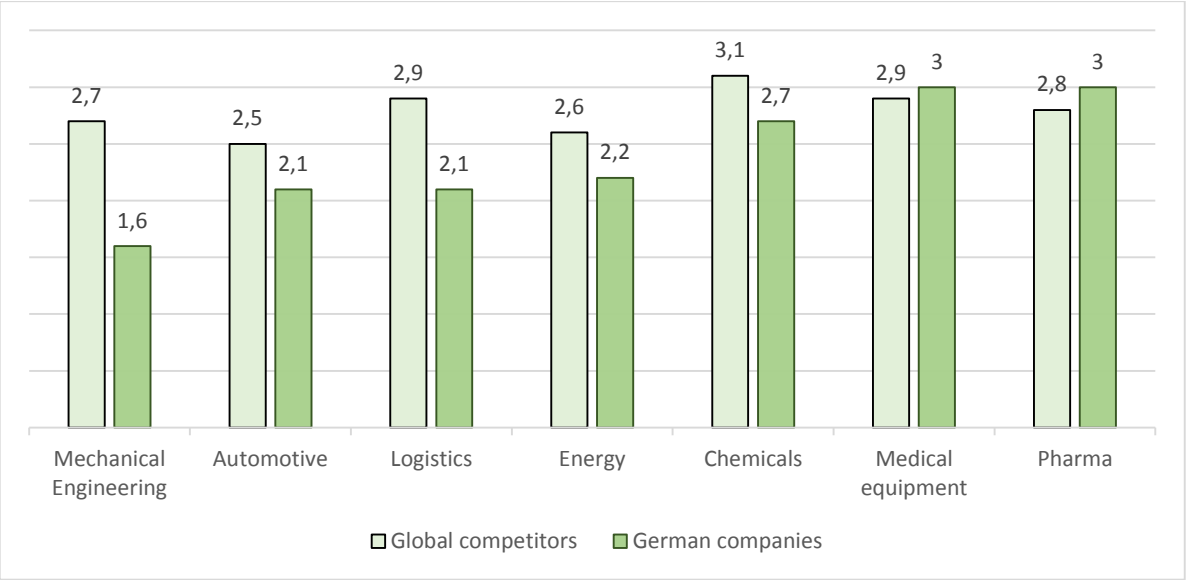

Figure 1: Digital competitiveness of Germany's leading industries.
Source: Own representation based on Kagermann et al. (2015, p.35).

Over the next years, German manufacturing companies are planning on investing a total of 40 billion Euros per year in industry 4.0 applications like Smart Services. Four out of five companies are going to digitize the whole value chain by 2020 (Strategy&, 2014, p.7).
According to a KVD study from 2014 the potentials of Smart Services are more and more recognized and also realized by companies. Particularly innovative companies distinguish themselves by a high degree of maturity of Smart Services (KVD Servicestudie, 2014). Additionally, a number of estimates indicate an efficiency enhancement of 6 to 8 per cent per year in manufacturing industries as a result of industry 4.0 innovations (Kagermann et al., 2015, p.14).

Because of the diversity of requirements to realize innovation in production environments and related processes like logistics and maintenance service, efforts for standardization are being made. Therefore reference models are seen as the infrastructures of success for the future. To be more precise, they offer a generic pattern for the class of system that is being modeled and its architecture. Research about logistic, machine and manufacturing processes are working on solutions to accelerate innovation processes based on these models (Kagermann et al., 2012, p.40ff). Thus, reference models should be designed including components that are needed to create the service-oriented infrastructure and give an overview about involved technologies. In this way, reference models enable the identification of research trends and gaps (Phillips-Wren et al., 2015, p. 453).

1.2. Problem and Objective

To successfully utilize Smart Services in the manufacturing industry, first of all there are specific answers to relevant questions needed:
What value can service suppliers provide for manufacturing companies through Smart Services and what management tasks have to be dealt with when implementing them? Which technologies enable the needed infrastructure to apply intelligent, data-based value-adding services in a production environment?

After having conducted a literature review, no reference model including the specific technologies and functions that enable the implementation of Smart Services in manufacturing industries was found. However, there were a few general reference models that roughly describe the needed infrastructure for Smart Services. Therefore, the reference model that is going to be designed in this thesis is targeted to answer the questions mentioned above, mostly so that researchers and service suppliers can use the model as a guideline and get an overview of the required technologies but also to get potential customers to recognize the development opportunities based on new business models.

Before that, a theoretical background is needed to define the meaning of Smart Services in general and also specifically for manufacturing industries as there are different definitions of what a Smart Service actually is and what it does. Thus, this thesis is focusing on the following two research questions:

RQ1: What are Smart Services and what role do they play in manufacturing industries?

RQ2: What technologies are required and what management tasks need to be performed to enable an appropriate service-oriented infrastructure for the implementation of Smart Services in manufacturing industries?

1.3. Structure of the Thesis

After the introduction, a short description of the used methodology within this thesis is given. The general research design of the thesis follows the instructions by Hevner et al. (2004).
To ensure an overall understanding about the topic and the field of research, there is a theoretical background given in section 3, firstly explaining the concept of industry 4.0 and the key enablers of innovation in a nutshell (section 3.1). Then the reader is being introduced

to various definitions for Smart Services (section 3.2.) and the role of Smart Services in manufacturing industries (section 3.3). After that, some existing reference models that were used as a base or inspiration for the final reference model are being presented (section 4.) The main part of the thesis is the design of a reference model in section 5. For this, a literature review was conducted to identify the needed components that enable Smart Services in the manufacturing industry following Webster and Watson's (2002) approach (section 5.1). Based on the literature review, the initial reference model was designed following the instructions by Schütte (1998) (section 5.2). Afterwards, expert interviews were conducted to improve the initial model and the analysis was done according to Mayring (2002) (section 5.3). In section 5.4 the final reference model was being designed and introduced to be discussed in section 6. At the end, a critical appraisal, a conclusion and outlook is given.

2. Description of the Methodology

In this section the scientific methods that were used in this thesis for the literature review, reference modeling and interview analysis are introduced. Moreover, to provide an overall clear and comprehensible structure for the thesis, a method for design science research (DSR) by Hevner et al. (2004) is described and also applied.

2.1. General Research Design of the Thesis by Hevner et al. (2004)

Hevner et al. (2004, p.1) find it fundamental to conduct a clearly and consistently structured research by implementing definitions, ontologies, boundaries, guidelines and deliverables to create "new and innovative artifacts". Thereby, they want to ensure a high quality design and execution of projects and a high acceptance not only among information systems experts but also for other audiences.

They consider DSR as an interaction of three closely related research cycles. Figure 2 displays those three cycles of the information systems research framework.

7. Critical Appraisal and Limitations

The target of this thesis to design a reference model for Smart Services in manufacturing industries was challenged by a couple of factors. Starting with the definition of Smart Services, it turned out that they are named differently by different authors but all indicating the same product. Whereas some authors talked about digital services, web-based services or IoT services, some others just mentioned innovative service solutions of the industry 4.0 in a Smart Factory. This complicated the literature review and restricted the search for relevant literature to some extent so that a further thorough research could add more important factors to the reference model.

Moreover, Smart Services are defined very differently in literature. On the one hand they are defined as completely autonomous services without human interface whereas on the other, authors explain the importance of humans as controllers while attributing different levels of smartness to the service. Thus, the designed reference model may not include all these definitions and their relevant technologies.

Furthermore, as the topic of Smart Services is rather new, literature only superficially describes technologies and needed infrastructures. Therefore the expert interviews were necessary to further amend the designed reference model. However only eight interviews are not sufficient. The model should be shown to more experts of different fields viewing Smart Services from different perspectives in order to create a completed reference model. In addition to that, not all suggestions made by the authors could be fully implemented to the model.
Nevertheless, the refinements that were made could have been shown to the experts to find out if criticized aspects of the initial reference model have now been solved, which could not have been done due to time restrictions.

8. Conclusion and Outlook

In this thesis, a new reference model for Smart Services in manufacturing industries was designed.

Taking into consideration the diversity of definitions for Smart Services in literature, in this thesis Smart Services were defined as digital connected, knowledge-based services exposing different levels of smartness at learning, adapting and decision making based on data retrieved, transmitted and processed, customized for the satisfaction of the users' need.

The created reference model includes a total of five layers. These layers step by step describe all relevant components and key functions that provide the needed SOA in order to apply different types of Smart Services. The difference in Smart Services refers to their level of smartness on the one hand, and the provider's and user's activity level on the other.
All components and key functions included in the final artifact resulted both from literature as well as from the interviews with experts.

Data being the main resource for Smart Services to learn from past experience and in this way improve processes to create value for the company spreads over all layers of the model.
To be more precise, starting from the physical assets of the factory where raw data is generated and collected up until the data integration layer, the model shows the processing chain of big data to gain valuable information about processes and machine conditions that Smart Services are built on and learn from. Along with this processing chain, various technologies and their key functions are included that pave the way for service innovations in the final application layer of the model.

The Smart Factory is an ideal concept of the industry 4.0 arising when data of a plant is vertically and horizontally integrated meaning that all processes within the factory and of all related facilities are digitized and interconnected. Through that, global facilities, augmented operators, social machines, virtual production and smart products are created. Combining these five components provides the SOA for all kinds of process optimizing services. However, huge traditional factories cannot change into Smart Factories as fast but still can use Smart Services when digitizing certain processes. Thus, completely evolving into a Smart Factory is an ideal but not a necessity.

In contrary to the introduced existing reference models by Kagermann et al. (2014), Fleisch et al. (2014) and Koschnick (2016), the layer model created in this thesis includes components and key functions in more detail and through that gives a more precise overview of involved processes.

Also relevant management tasks were included in the model as besides technological requirements also organizational ones have to be met in the application process of new services.

Considering the demand for standardization to meet the diversity of requirements when applying Smart Services in different kinds of ecosystems the proposed reference model offers a generic pattern for the implementation of Smart Services in manufacturing industries. It can accelerate innovation processes and allow the identification of research trends as Smart Services are seen as important competitive advantages. In other words, the model can be used for the purpose of research, for solution providers when engineering new products and for manufacturing companies to get an overview of involved technologies and through that identify development opportunities.

Regarding the variety of Smart Services, the reference model is adaptable for those meant for B2B settings, thus, not considering Smart Services for after-sales and customer settings but those meant to improve manufacturing processes.

Furthermore, the model can be reused indicating that the results can be adopted and further adapted for the purpose of other reference models concerning Smart Services. In other words, one might be able to take the identified layers and exchange several components adapting them to other ecosystems.

This thesis did not consider the application of the reference model to realize innovative business models. However, this can be subject of further research.

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