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Product-Service Systems across Life Cycle

Innovative services for customized, availability-oriented business models for the capital goods industry

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Abstract

Manufacturers of capital goods are subject to high requirements regarding availability and productivity. Services give manufacturers the opportunity to expand technical products and to fulfill all customer requirements. Solution concepts that consist of a union of technical products and services are called Product-Service Systems (PSS). For the realization of PSS, the capital goods manufacturer (PSS-provider) must collaborate with each participant of his extended value-added network. The extended value-added network consists of members of the development, production and service. This cooperation and complete interconnection with each participant provides the foundation of the development and offer of availability-oriented business models. This paper presents an approach for PSS which enables innovative services for the extended value-added network and for the customers in order to realize customized, availability-oriented business models. The approach is based on three sub-goals. First, development of PSS and customized, availability-oriented business models. This goal is presented in the paper. Second, development of smart components for collecting and processing of service relevant data. Third, design and configuration of an information management platform to provide and exchange service relevant data.

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Keywords: services, availability, business models, capital goods industry

1. Introduction

Capital goods are subject to high requirements in productivity and availability [1]. Customers require integrated solutions combining products and services. So called Product-Service Systems (PSS) enable this combination. PSS are realized by purchasing capital goods and additional acquisition of specific and useful services [2]. However, function-oriented business models are only partially adaptable to dynamic markets and fluctuating customer demands. Contrary to this, availability-oriented business models guarantee the operational capability of capital goods. Thereby, manufacturers of capital goods insure the agreed availability by implementation of suitable services [3]. It has to be taken into account, that these business models can only be implemented, if every partner in the extended value-added network (product development network, manufacturing network and service-network) are fully interlinked and share relevant information with each other. In spite of increasing demand for guaranteed availability, manufacturers do not want to provide this. Reasons are high costs due to high risks and uncertainties resulting from missing operational data, customer behavior and insufficient transparency of machine condition. In addition, essential data management to handle a vast amount of information is insufficient.

The presented approach overcomes the described deficits by using upcoming internet-based technologies in context of Industry 4.0. An overview of the state of the art of PSS and business models is given. The main part presents the approach how to develop innovative services for customized, availability-oriented business models for the capital goods industry. In addition to that, a brief summary on further activities is given.

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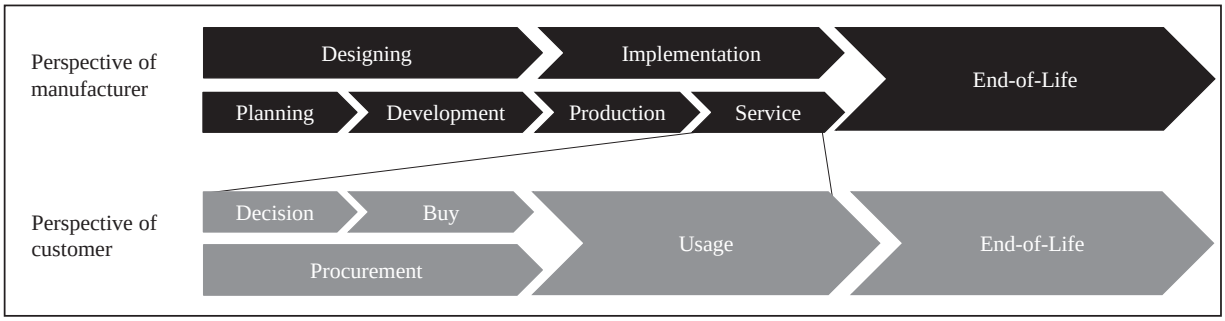

Figure 1: PSS life cycle from the perspective of manufacturer and customer [2]

2. State of the art

2.1. Product-Service Systems in extended value-added networks

Customers require integrated solution concepts that can be served by offering technical products with services. Product-Service Systems (PSS) are such a solution concept which combines products and services. It is a marketable concept and enables to fulfill customer´s need [4]. According to Lee et al. PSS aim to achieve sustainability and customer satisfaction by systematically integrating various elements with products [5]. PSS are also defined as a system of products, services, networks of actors, and supporting infrastructure [6]. The aims of PSS are to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models [6]. PSS are characterized by the integrated and mutually determined planning, development, provision and use of product and service shares and represent a “knowledge-intensive socio-technical system” [7].

The life cycle of PSS is more comprehensive than the life cycle of a single product. The manufacturer respectively PSS-provider offers his customer a cooperative partnership during the usage of his product. Manufacturer and customer act as internal and external production factors during the whole work process [2]. Because of the customer-oriented instead of product-oriented perspective, the life cycle of PSS is not only considered from the PSS-provider but also from the customer´s perspective [2]. Figure 1 presents both life cycle perspectives. From the perspective of the manufacturer the life cycle of PSS consists of the three main phases Designing, Implementation and End-of-Life. During the Designing phase products and services need to be developed integrated and a customer-specific configuration of the product and service components should be done. For the customer the life cycle starts with the Procurement and ends with the End-of-Life [2].

PSS-provider or one single company cannot independently create, deliver and capture PSS value [8, 9]. For offering PSS successfully manufacturers need to cooperate with the extended value-added network (see Figure 2). That extended value-added network consists of the development network, production network and service network of a PSS-provider [2]. This kind of network is also called value creation architecture for PSS [10, 11]. Both wordings define a network organization in which PSS-provider, customer and suppliers work together to achieve the highest value of PSS. Missing capacities or limited resources from the PSS-provider can be completed by suppliers [7]. Although knowledge and experience of PSS business models are limited [12], different researchers emphasize the importance of the relationship with external partners when implementing a PSS business model [8, 13].

2.2. PSS for availability-oriented business models

Current available technologies and an intensive use of Internet also in terms of business activities and processing provide new opportunities for developing innovative business models. In a broad definition, business models are the economic model of an enterprise in order to generate value and

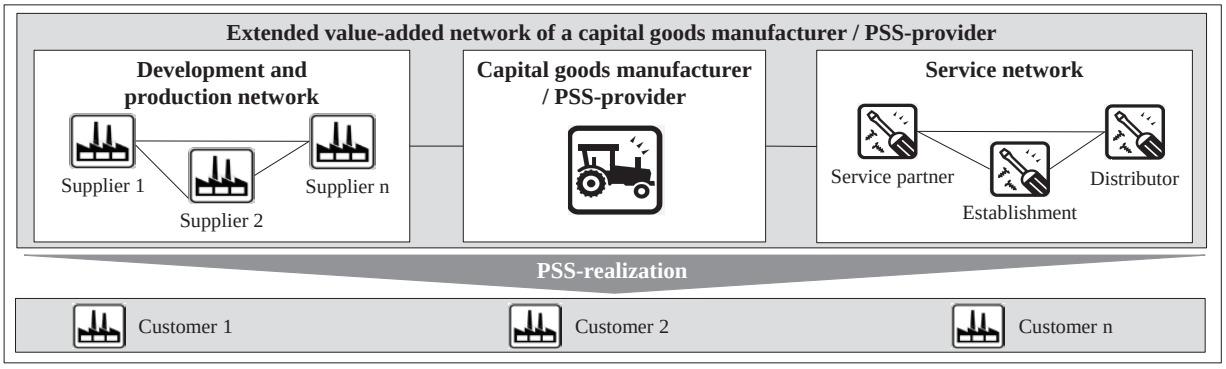

Figure 2: Extended value-added network of a capital goods manufacturer / PSS-provider

to gain competitive advantages [14]. Furthermore, they describe how to receive and transform resources with help of internal processes to generate value-adding information, products and/or services [15].

In the current literature, different PSS types are analyzed to help companies when shifting towards a service-oriented business model [16]. One framework based on the Canvas model is presented by Adrodegari et al. which was carried out by an explorative survey with European companies [17]. Nevertheless, this framework is limited to the transportation, automation and machinery industry and is not generalizable.

In general, business models can be elaborated and visualized with the following nine elements (business model canvas) [15]. The first element is called customer segment. Here, the addressed target customer groups are defined. The second element explains how customer needs will be fulfilled by the offered products or services (value proposition). Third, communication-, distribution- and sales channels are characterized. In the next element, the relationship between customers and the company is described (customer relationship). The element revenue streams clarify, how revenue is generated by means of the specific business model. The elements key resources and key activities outline the main resources and the main activities in the company to offer the business model. The structure and organization of supplier networks and partners are determined in the element key partners. Each single element impacts the cost structure. The costs for the specific business models have to be drawn up in this last element.

PSS enable innovative function-, availability- or result-oriented business models [7] and new business models with the aim to fulfill customer´s needs [18, 19]. In this paper, only availability-oriented business models are in focus and described. Availability-oriented business models use PSS to guarantee the usability and availability of products for the customer. The PSS-provider takes responsibility of the business processes of the customer and takes a part of the production risk [7].

Generally, services can be classified in the three life cycle phase´s Procurement, Usage and End-of-Life [20]:

- Procurement: Services which support procurement, e.g. consulting, leasing.
- Usage: Services like commissioning, hotline service, condition monitoring, training or maintenance.
- End-of-Life: Services like retrofit, remanufacturing, resale of used machines or disposal.

According to [7] services can be classified in procurement and use phase in seven types: planning, counseling, training, logistic, function creating, function maintaining and optimizing services. However, services can also be differentiated by their functionality in technical, qualifying, process-oriented, logistical, information-providing or financial support services. Technical services enhance the technical product whereas qualifying services support the qualification of customers´ employees. Process-oriented services improve the production process [21].

Services can also be differentiated according to their business model. According to Parida et al. maintenance and product support services are services for product-oriented business models [22]. Research and development as well as functional services are classified as services for user or result-oriented business models [22]. Mori Seiki and NILES-SIMMONS offer standard after sales services for their functional-oriented business models like spare parts, field service and training for the customer staff [7]. A preliminary stage of services for availability-oriented business models are service contracts and remote services. Remote monitoring is the basis for service process integration. Services for availability-oriented business models should be service initiatives on the manufacturer side [7]. An example for availability-oriented business model presents Rolls Royce. They offer “Power by the hour” for airlines who pay the functionality of the engine operation and receive services as an integrated part of the offer [23]. These kind of services are based on a multi-actor collaboration between OEM, suppliers, third party partners and customers [23]. For example, the chemical industry company BASF offers a cost per unit model. BASF takes responsibility for their costumer´s painting processes in the automotive industry. They are integrated in the manufacturing process of the customer and can affect efficiency improvements. Savings in lacquer consumption are shared by all partners. The payment is performance-related for every proper painted body [24]. The company Wollschläger realizes another example for a service contract where the customer pays a fixed amount for the service every year. Wollschläger is a trading company which offers a tool cabinet based on remote service technology to its customers. They are able to control the need and availability of tools at each moment and can react in real time. Using remote service offers new kind of services like machine benchmarking and enables the manufacturer to provide their existing services quickly and cost efficient [7]. The extended value-added network is fundamental for realizing these kind of services. Nonetheless, according to a study only few PSS-providers cooperate with external actors while most of the PSS-providers are conservative regarding involvement of external actors to support PSS offers [22].

In summary, services for availability-oriented business models guarantee the usability and availability of the means of production. The PSS-provider takes the responsibility of the business processes of the customer and takes a part of the production risk [7].

3. Research gap and new research goal

In spite of the existing and increasing demand of guaranteed availability for capital goods, manufacturers avoid offering guarantee contracts. Customers are not willing to pay for the contracts since high risks and costs are not in relation to the value. The risk originates in missing operation data and lack of transparency of customer´s behavior and current state of the machine during the use phase. Due to internet of things, operation data is available and smart, connected products

enable new set of product functions and capabilities as well new innovative services. Nevertheless, a challenging aspect for companies is to use the operation data and to build and support an entirely new technology infrastructure [24]. Porter and Heppelmann define a “technology stack” made up of multiple layers, product hardware, embedded software, connectivity, product cloud and security tools [24].

According to the survey of Parida et al., high-value adding services have a positive influence on performance. Maintenance services provide the highest financial return for manufacturing companies. As a conclusion of this survey, it is recommended to develop a diverse-set of PSS portfolio including simple as well as complex PSS to generate higher value for customers and secure future competitiveness [22]. Availability-oriented business models offer the possibility to develop a PSS portfolio with customized services to achieve the highest PSS value. Currently, there is rare knowledge and experience according to PSS business models [12].

PSS literature has not discussed business models extensively [25]. There is a paper with a framework for service-oriented business models which includes a set of variables for business model configuration in servitization contexts [26]. The development and design of dynamic business models for PSS is presented in a dissertation [27]. However, these business models are not focused on guarantying availability and offering customized services. Furthermore, there is still a research gap how PSS business models can be implemented. Reim et al aim to develop a better understanding for implementing PSS business models and present a literature review of how business models and their associated tactical practices are implemented [8]. Nevertheless, the following chapter presents an innovative approach to bridge the research lack of availability-oriented business models.

4. Approach for customized, availability-oriented business models

Main objective of approach is the development and implementation of innovative services and information processing to realize individual and availability-oriented business models for capital goods. Contrary to existing concepts [28] (e.g. condition monitoring), this approach allows to develop business models in consideration of related impacts for the extended value-added network. To identify and select innovative services, an analysis on interactions among partners of the extended value-added network is helpful and will be considered. To achieve the overarching objective, three sub-goals are defined:

1. Development of customized, availability-oriented business models
2. Development and integration of smart components with the ability to communicate
3. Design and configuration of an information management platform to provide and exchange service relevant data.

The development of customized, availability-oriented business models is in focus of this paper. Therefore, two use-cases are given by different OEMs of capital goods. Afterwards, a generalized framework for the development of availability-oriented business models will be enhanced to ensure the broad applicability. This generalized framework will be applicable for any size of company and for different industries. Therefore, an additional use-case will be determined to guarantee the adaptability across different industries.

4.1. Analysis of requirements for innovative services in customized, availability-oriented business models

The approach starts with the analysis and specification of two use-cases given by different OEMs. The use-cases have to be investigated and described regarding the involved products

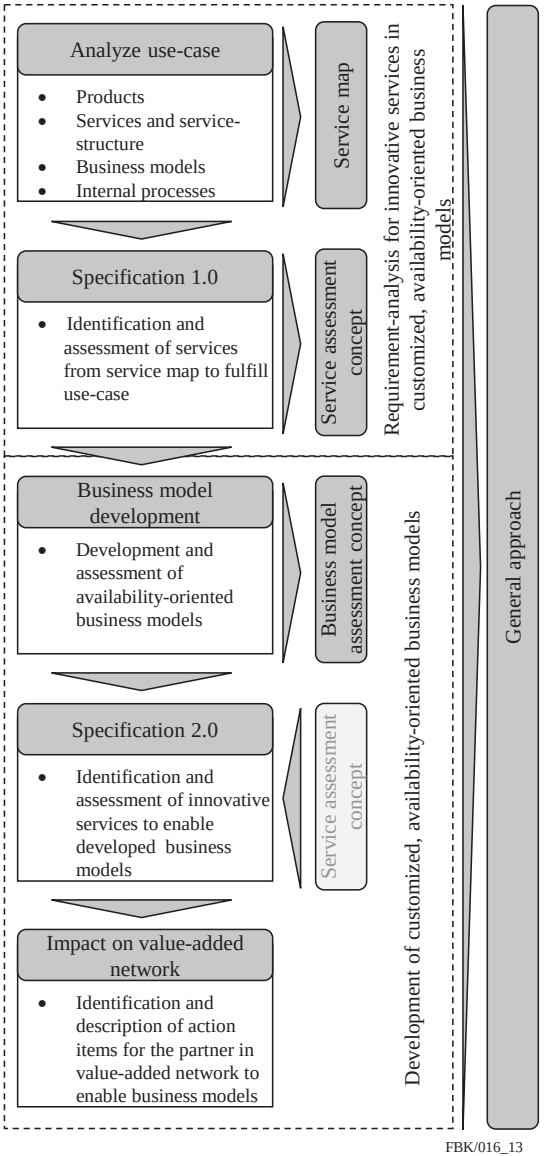

Figure 3: General approach to develop customized, availability-oriented business models

and implemented services. In addition, the current state of business models, internal processes and service-structures are analyzed. One important task is the preparation of service maps for each company. These maps serve as an overview of all provided services and correlations between them in a useful manner.

Services to fulfill the use-case requirements have to be identified and assessed based on the service maps. Useful services will be listed in a so called “Specification 1.0”. To assess these services, specific criteria regarding customer value, service interfaces and service performance need to be developed. In addition to the specific assessment, a general approach to identify, analyze and assess services for capital goods is elaborated. Therefore, the use-case specific criteria have to be generalized and extended to generate a broad criteria catalog.

4.2. Development of customized, availability-orientated business models

The overview of the introduced approach and the process flow is shown in Figure 3. Derived from the use-cases and identified services, customized, availability-oriented business models have to be developed for each enterprise. This activity takes place in close coordination with the specific enterprise using business model canvases. Thereafter, different business models have to be assessed and prioritized. In doing so, company-specific criteria will be identified in different workshops with suitable experts. After the assessment, the most promising business models will be selected.

In the next step, further and innovative service-ideas have to be identified to fulfill the requirements derived from the assessed business-models. Therefore, different workshops and idea-finding processes need to be conducted with the companies and their partners in the extended value-added network. The innovative services have to be assessed with the service assessment concept from the first part. After that, useful innovative services complement the Specification 1.0 and lead to the Specification 2.0. With these results, the impact of the new availability-oriented business models and the new innovative services have to be examined for each partner in the extended value-added network. Based on their current situation, need for action have to be identified to fulfill the requirements. These action items need to be characterized and combined to a master plan to operationalize the development and implementation of new services. Changes and new additional information regarding the services are updating the Specification 2.0. In addition to this, a general approach and set of tools is developed to identify, describe and operationalize services, Product-Service Systems and availability-oriented business models for capital goods manufacturers and their extended value-added network. This includes necessary steps, methods, tools and aspects to describe a transparent approach for companies to implement customer-oriented services to provide availability-oriented business models.

4.3. Further research activities

The following chapter shortly outlines the subsequent content of the upcoming activities and describes the further activities.

Based on the developed business models and relevant services (Specification 2.0), smart components with the ability to communicate will be developed. A cloud-based and secure communication platform need to be established to manage all service relevant information. A special focus is set on intellectual property rights with the ability to place different rights for manufacturer, supplier and service provider. This platform includes a back-end to guarantee a consistent and broad data base for service-oriented products and process information. To handle the amount of data, information will be analyzed with methods and logics by means of data mining and business analytics/business intelligence. Additionally, a front end is part in the platform. Here, a hardware independent concept will be developed to visualize relevant data.

4.4. Prototypical implementation and approach validation

The development of new availability-oriented business models, the respective innovative services to realize them, and the communication platform will be implemented in the specific use-cases to validate and improve the approach. For further validation, a standardized concept has to be developed. Therefore, a criteria catalog will be established to compare the validation results. The outcome obtained from different test and validation will be communicated to all partners in the extended value-added network to initiate further need for action. With the help of this iterative enhancement, the results will be improved continuously.

5. Conclusion

Due to dynamic markets and fluctuating demands, customers ask for guaranteed availability of capital goods. Therefore, availability-oriented business-models need to be established and provided. Because of different given uncertainties, manufacturer of capital goods do not provide those. In the presented paper, the focus is set on the development of availability-oriented business models. Thereby, two use-cases from OEMs are given. A service map with all relevant services and their interconnections is prepared based on the analysis of the use-cases regarding products, services, and business models. Availability-oriented business models will be elaborated, assessed, prioritized and selected. In workshops with different experts and partners from the extended value-added network, innovative service-ideas will be identified and assessed to realize these business models.

Derived from this, action items for the partners in the extended value-added network will be identified. Parallel to the use-case specific elaboration, a general approach will be developed for companies to implement customer-oriented services for availability-oriented business models.

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