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INTERACTIVE MODELING AND EVALUATION OF PRODUCT-SERVICE-SYSTEMS

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ABSTRACT

Product-Service-Systems (PSS) are an opportunity for differentiation within the globalized producing industries. The design of PSS concepts challenge companies and question their generic business model. As a result, companies have to cope with complex activities ‘opportunity recognition’, ‘PSS design’ and ‘business planning’ without the support of an integrated approach that is easily understood and applicable by all collaborating stakeholders with a minimum of training. The objective is the development of a modeling procedure for PSS which supports a systematic variation of its typical properties and allows interdisciplinary interaction in teams. The paper presents a business model canvas, a PSS-life-cycle and PSS-configurator imbedded in a procedural model. The methods as well as the procedure are evalueted by 3 case studies with industrial partners. Furthermore, the case studies investigate the influence of the derived methods on the product/service-ratio of the provided solutions of the industrial partners within the case studies. Finally, the paper gives an outllook on the enabled strategic evolution of a company’s generic business model to a business model of a PSS provider.

Keywords: design methods, collaborative design, service design, PSS

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1 INTRODUCTION

1.1 Motivation

Through globalization producing industries in highly developed countries are facing competition from (former) emerging economies which they often cannot outperform by price. According to Porter (1985) this is a reason for a shift in strategy from a leadership of costs to differentiation. A prominent opportunity for this differentiation is the concept of product-service systems (PSS) which Goedkoop et al. (1999) define as a marketable combination of products and services capable of jointly fulfilling a user's need. The product-service ratio in this set can vary, either in terms of function fulfillment or economic value. The design of a PSS concept is related to the activities of 'business planning' and 'opportunity recognition' through the cycle of strategic product planning, one of the cycles of product development (Figure 1).

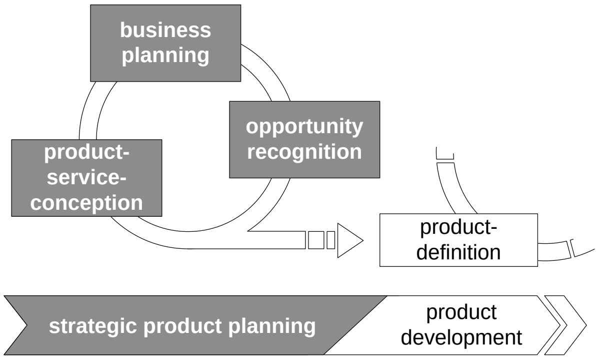


Figure 1. Cycles of product development according to Gausemeier et al. (2006)

The cycle of strategic product planning contains the initial activities necessary to develop a concept from a PSS idea, which represents the starting point for product development. Because of the immense influence on the product definition, an approach, consisting of a procedure and methods, applied in the design of PSS needs to be well considered.

For the design of a PSS concept the variety of possibly involved stakeholders encompasses corporate management and all functions of the value chain, with a focus on product-development and service-design. A wide range of modeling languages and meta-models for the description of both 'business plan' (Schafer et al., 2005) and PSS (Becker et al., 2009) exists, but an integrated, applicable approach has not been developed so far. Existing research emphasizes the importance of integrating various stakeholders into the design process of PSS (Velamuri et al., 2012). Hence, the challenge consists in joining the complex activities 'opportunity recognition', 'PSS design' and 'business planning' in one integrated approach that is easily understood and applicable by all collaborating stakeholders with a minimum of training.

The main objective of this study is the development of a modeling procedure for PSS which supports a systematic variation of its typical parameters and allows interdisciplinary interaction in teams and groups. This approach will consist of phases and steps, suggested methods and tools. Besides, the procedure is supposed to consider the relation between the attributes of the PSS and the elements of a business model (BM) in order to ensure the integrated character of strategic product planning. This makes an evaluation of a PSS concept or different scenarios possible.

For the investigation on the topic the research class of applied science was chosen and subsequently the following two research questions were phrased:

1. How does the elaborated approach influence the scenarios of product-service systems as measured by the product/service-ratio?
2. Which yet unknown factor has a main influence on the relation between the approach and the product/service-ratio?

1.2 Background of Research

The innovation of product-service-systems as combination of hardware, software and services is characterized and influenced by a number of company-internal and external cycles. These cycles are objects of investigation of the Collaborative Research Centre (SFB 768) – ‘Managing cycles in innovation processes – Integrated development of product-service systems based on technical products’. Cycles are reoccurring patterns (temporal and structural), which are classified by phases. As a result, a cycle is always characterized by repetition, phases, duration, triggers and effects. Moreover, cycles may include retroactive effects, interlockings, interdependencies (within cycles and between cycles), hierarchies and further influencing aspects. (Langer & Lindemann, 2009; Knoblinger & Lindemann, 2010) The fields of action of the SFB 768 are to manage innovation processes and their inherent cycles, control dependencies and strengthen the solution creation. This paper focuses on the combination of PSS/BM methods.

2 RESEARCH METHODOGOLOGY

In order to elaborate an approach for the systematic design for PSS the design research methodology (DRM) introduced by Blessing (2004) was chosen because it provides a commonly accepted support for experiments and validation in the field of design research. As DRM is not a purely sequential process, iterations may take place, and stages may have to run in parallel (Blessing, 2004). This was considered when building the study’s structure, which is represented in Figure 2.

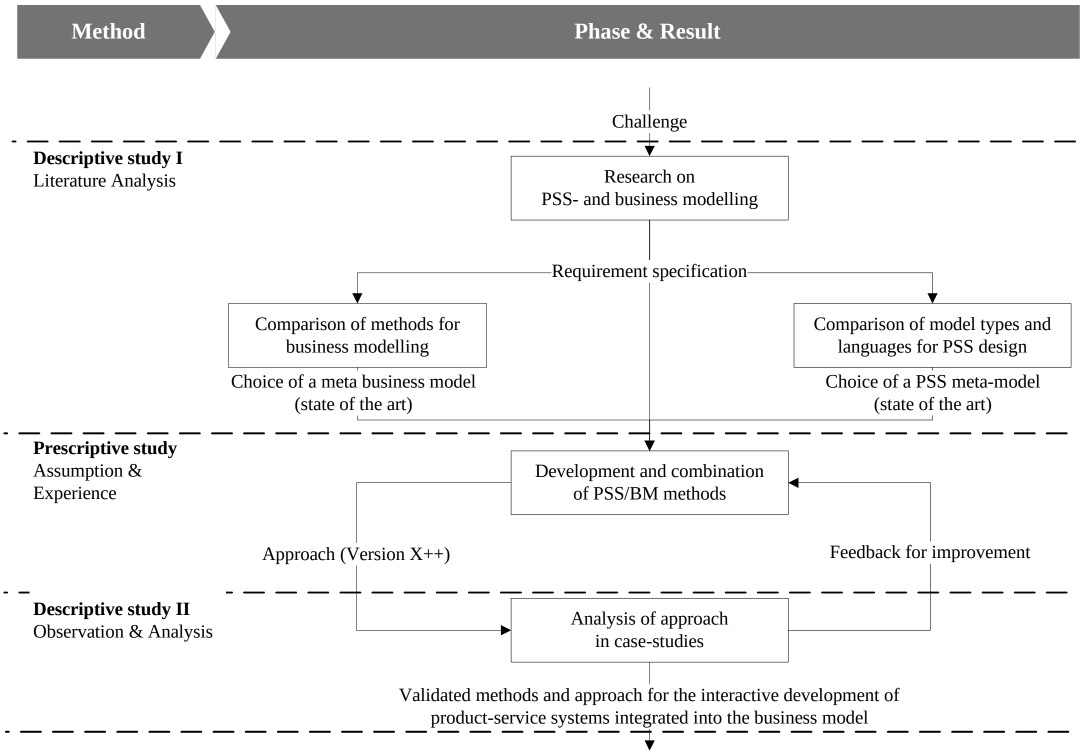


Figure 2. Flow chart of the study’s structure modeled after Blessing (2004)

Figure 2 shows the flowchart of the study’s structure from the challenge to a validated approach and implied methods for the interactive development of product-service systems integrated into the business model. The initial challenge defined a scope for the literature analysis which considered publications from a systematic literature review performed by Velamuri et al. (2012), complemented by an own literature analysis inducing a total of 48 relevant publications. Requirements for a systematic, interactive approach were documented, which provide a basis for the choice of a meta-model for business modeling and PSS design in the first step and their development and combination in the second step. The elaborated approach was successively applied in three case studies and improved along the feedback of the participants. This iterative loop was performed three times with different companies resulting in a validated approach which is presented in chapter 4.

3 STATE OF THE ART IN PSS- AND BUSINESS MODELLING

3.1 Service blueprint

The state of the art in modeling PSS is described in Becker et al. (2009), where 14 modeling methods are presented. The publication describes modeling methods and languages from abstract levels like the unified modeling language (UML) (Weilkins, 2006) to specific PSS modeling methods like the Service Engineering approach (SeeMe) by Herrmann & Loser (1999). Considering the requirement specifications with emphasis to the demand for the methods to be understood and applicable by all collaborating stakeholders with a minimum of training the method of ‘service blueprinting’ (Bitner et al., 2007) was taken into consideration as shown exemplarily in figure 3.

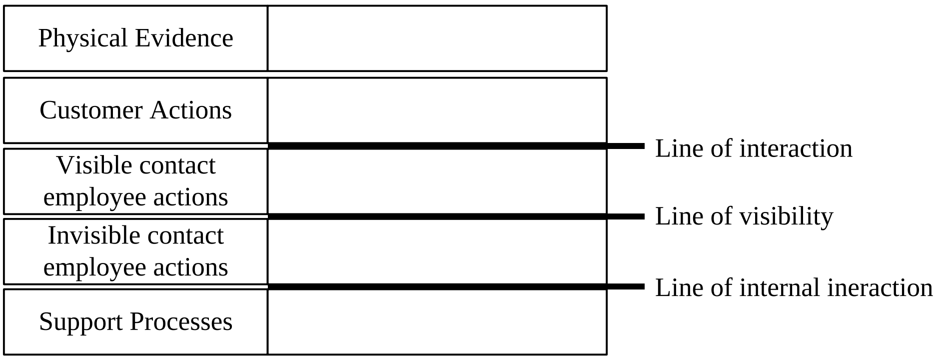


Figure 3. Components of a service blueprint (Bitner et al., 2007)

Figure 3 shows bottom-up the supporting processes of backstage-, onstage- and customer actions, as well as their physical evidence in the upper line. The actions of an assessed service process can be documented in the lines on the right side. They are top-down separated by the line of interaction, visibility and internal interaction, each declaring the meaning of a crossing relation.

3.2 Business model ontology

The state of the art in business modeling is based on the business model ontology by Dubosson-Torbay et al. (2002), described in detail by Osterwalder (2004). This ontology contains the most prominent components compared to the ones used in 12 common business models in a review by Shafera et al. (2005).

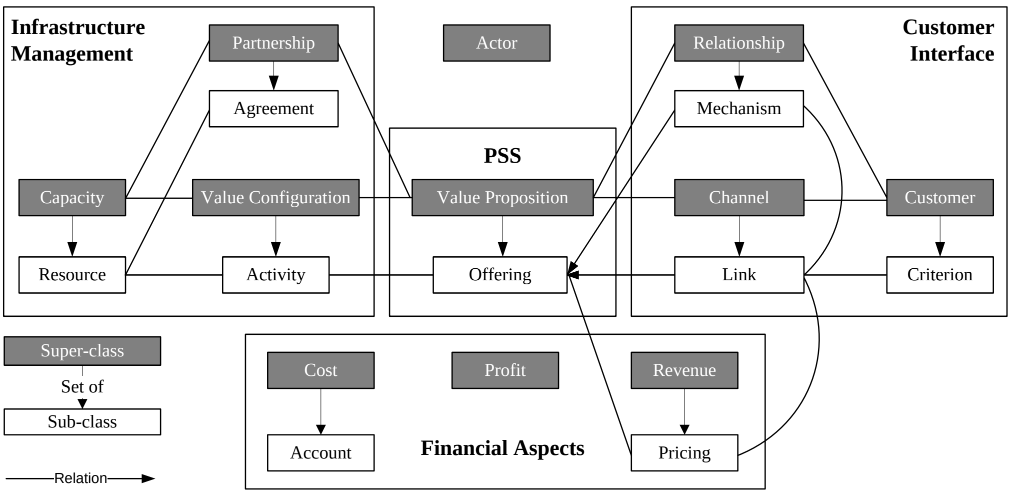


Figure 4. Business model ontology (Osterwalder, 2004)

The business model ontology contains 11 super- and sub-classes (actor, partnership, capacity, value configuration, value proposition, relationship, channel, customer, cost, revenue, profit) separated in four domains (infrastructure management, PSS, customer interface, financial aspects) to describe the business logic of a specific company. Some classes are directly linked, like offering and price, while others (e.g. costs) have to be derived from the individual structure of a specific business model.

3.3 Business model canvas

The business model canvas was developed by Osterwalder & Pigneur (2010) and is based on the previous described business model ontology condensed to the framework shown in figure 5. It divides a business' logic into 4 domains, each consisting of one to three components supplemented with a key question to stimulate interacting stakeholders when analyzing or developing specific business logic.

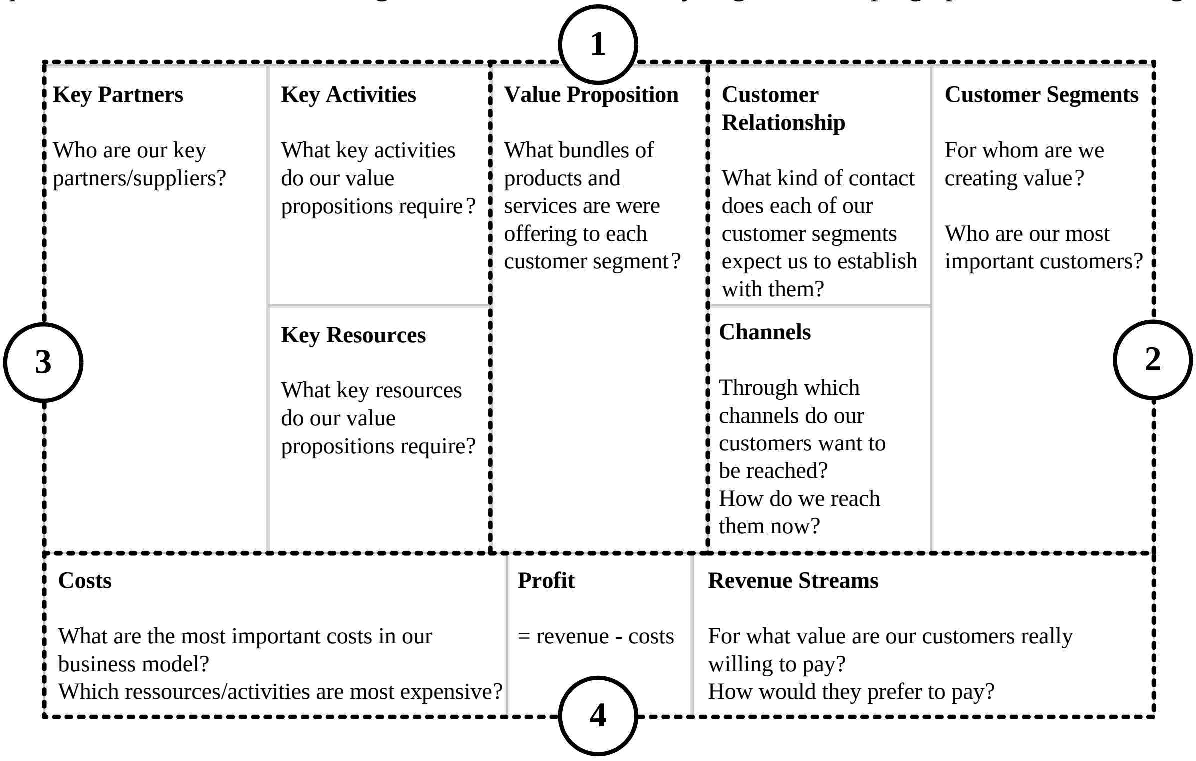


Figure 5. Business model canvas (Osterwalder & Pigneur, 2010)

The domains are numbered in the sequence of application, proposed by Osterwalder & Pigneur (2010):

1. Value Proposition: This domain solely consists of the value proposition, in our case the PSS.
2. Customer Interface: The customer segment determines the relationship and channel according to the offered PSS.
3. Infrastructure Management: Once the value proposition and the customer interface are set, the activities and related resources can be defined. If they are not key activities or –resources, key partners need to be acquired to outsource those activities or respectively use their resources.
4. Financial Aspects: The last steps are to define the costs (fixed and variable costs, interest rates, etc.), estimate the revenue streams and finally calculate the profit of the business model.

The business model canvas fosters the mapping of mental models (Osterwalder, 2004) by their visualization. It improves the understanding of the system, especially of its domains, components and their relations. The method should be used when planning a PSS before elaborating a financing plan. In the words of the UML the business model canvas results in a structure diagram, whereas the following modeling method results in a behavior diagram.

The service blueprint and the business model ontology are powerful methods within their disciplines (service design and business design), however an approach or method linking them in a way that is applicable for a group or team with an interdisciplinary background has not yet been developed.

4 RESULTING APPROACH AND METHODS

The result of the study is an approach for the interactive, model-based design and evaluation of PSS, consisting of a procedure and embedded methods, two of which are state of the art and two are new. The detailed process and the new methods within were successively improved to the presented state, based on the feedback of three teams of industrial partners who participated in three workshops according to Figure 2. The procedure presented in sub-section 4.1 illustrates the phases of the developed approach and the related activities, as well as the applied methods. The new methods will be presented in section 4.2. For a better understanding of the methods benefit, they are introduced with excerpt data, gathered from the third workshop.

4.1 Procedure for interactive modeling and evaluation of PSS

The phases of the procedure for interactive modeling and evaluation of PSS are presented in the second line of figure 6. They are derived from an outtake of the ‘munich procedure model’ for product development (Lindemann, 2009) presented in the first line. Thereunder the phases are subdivided into activities which are performed with use of the methods, denoted in the boxes ranging across the phases they are linked to. Connecting arrows show the in- and outputs of each method.

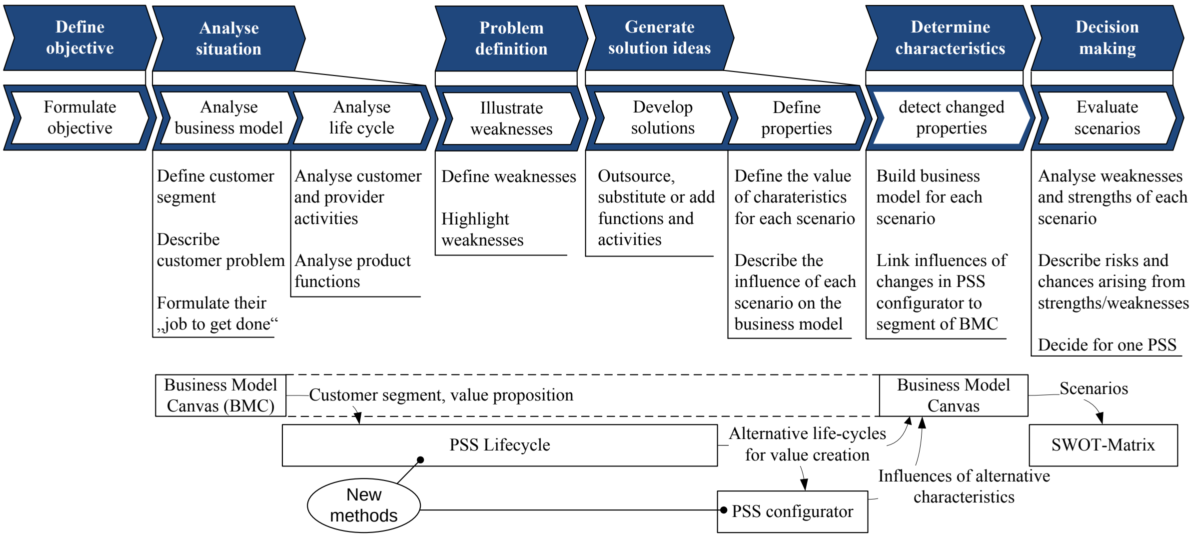


Figure 6: Procedure for the interactive modelling and evaluation of PSS

The order of the phases in the procedure shown in figure 6 is recommended for modeling and evaluating a PSS in the context of its business model, but it may be adapted to the given situation if the output of a phase is already know, e.g. one may analyze the properties of a given PSS with the PSS configurator to define the alternative values of the property. In order to comprehend the benefit of each phase and to decide about the necessity of an adaption, the following sub-section introduces the methods for modeling a PSS’s business model and its inherent problems, the life-cycle of a PSS in a blue print approach and the systematical definition of typical PSS characteristics.

4.2 Methods for interactive and systematic modeling of PSS

PSS life-cycle

Service blueprinting initially was a process control technique to identify and solve failure points in service operations. According to Bitner et al. (2007), its main advantages are a customer-focused point of view on the process as well as the differentiation of front- and backstage activities. The service blueprint introduced in section 3 was strongly adapted to the requirements of PSS design. The following, new blueprint was named “PSS life-cycle” (figure 7) and was designed with respect to;

1. the demand for a holistic view on all phases of the life-cycle and
2. the focus on product functions instead of its physical representation.

The first steps for modeling a PSS life-cycle is performed by filling out the first line, shown in figure 7. Initially the customer segment needs to be defined, because every PSS is supposed to cater to the specific needs of a group with common characteristics (Becker, 2008). Afterwards the customers problem or ‘pain’ is defined to deduce a need or, in the language of PSS, the customers’ ‘job to get done’. The lines of the blueprint are defined as products, services, networks and infrastructure according to the definition of PSS by Mont (2002). Manzini & Vezzoli (2003) determine that stakeholders usually optimize a PSS in the specific sub-system which they are aware of instead of seeking an optimum for the whole system. As a result, the model shown in figure 7 supports different disciplines with a view on all phases of the system life-cycle from conception to disposal, based on the field of systems engineering (Blanchard & Fabrycky, 2008). These phases can be found in the process-shaped column-headers in figure 7. The phases ‘Operation, Maintenance, Support’ are summed up in one bold column considering the importance of the use phase which according to Mont (2002) should be focused on in the development of PSS. The meaning of its rows is described in table 1.

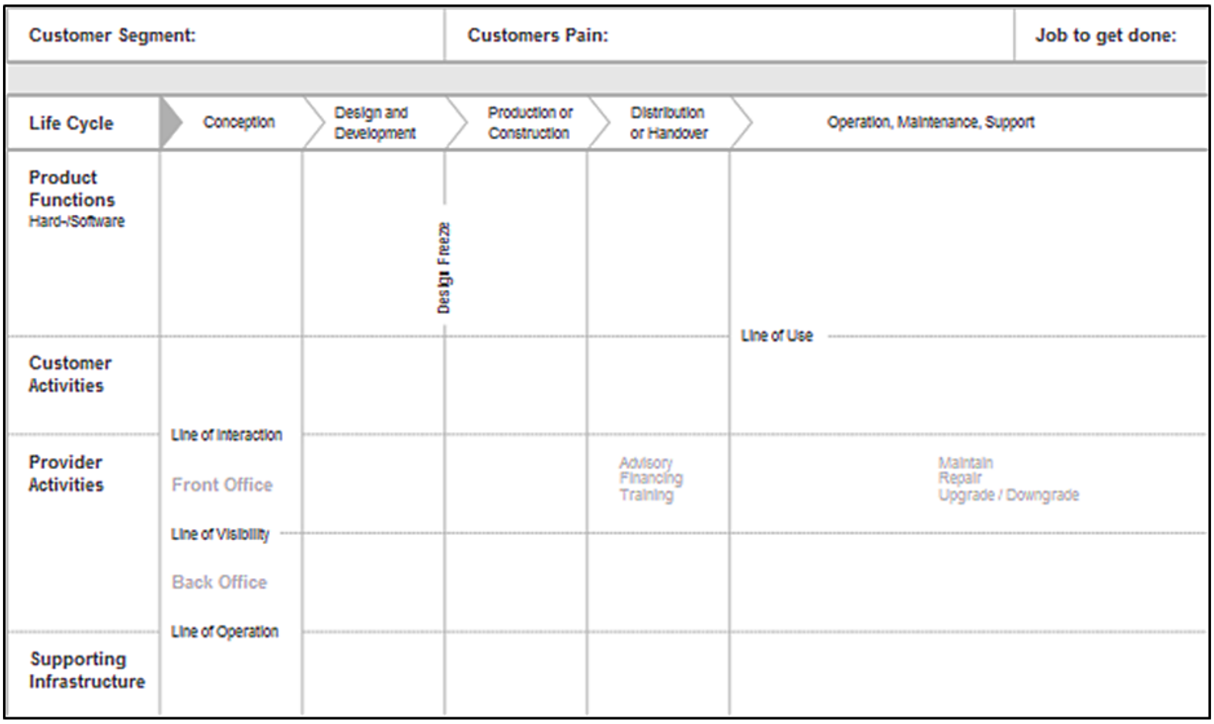


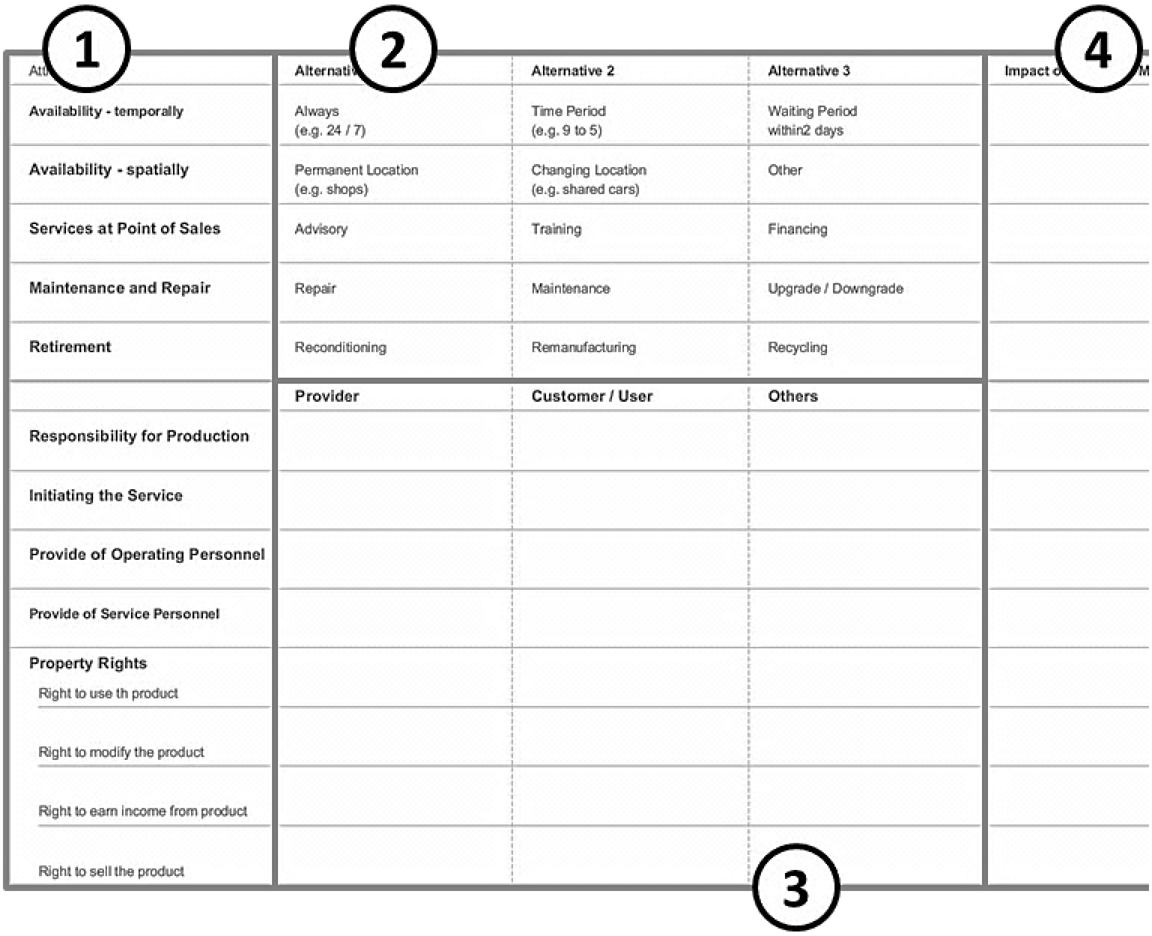
Figure 7. PSS life-cycle (excerpt)

Table 1. Description of domains and lines in the PSS life-cycle

Domain or line	Explanation
product functions	Description of a products function necessary to ‘get the customers job done’ (combination of noun and verb)
line of use	This line is of special importance, because different profiles of use are a central aspect in the design of PSS (Mont, 2002). This line is crossed if a product function is used.
customer activities	Description of customer activities (combination of verb and noun).
line of interaction	Crossing this line implicates interaction between provider and customer.
line of visibility	All elements above (below) this line are (in-)visible to the customer.
provider activities	Functional description of provider activities, separated into front and back office, divided by the line of visibility (verb and noun).
line of operation	Crossing this line means integrating supporting infrastructure in order to support an activity or product function.
supporting infrastructure	Description of infrastructure that might be necessary to support activities of product functions (may be described with a noun).
network	In this column, activities, functions or infrastructure which is provided by partners or suppliers may be modeled.

PSS configurator

The new PSS configurator in figure 8 represents the most detailed stage within the approach. It enables a systematic configuration of typical PSS properties within the given solution space (Ehrlenspiel, 2009) represented by a range of property-values. Each configuration forms a unique PSS and, in combination with the business model canvas and the PSS life-cycle, a unique PSS scenario.



Att	Alternati	Alternative 2	Alternative 3	Impact o
Availability - temporally	Always (e.g. 24 / 7)	Time Period (e.g. 9 to 5)	Waiting Period within2 days	
Availability - spatially	Permanent Location (e.g. shops)	Changing Location (e.g. shared cars)	Other	
Services at Point of Sales	Advisory	Training	Financing	
Maintenance and Repair	Repair	Maintenance	Upgrade / Downgrade	
Retirement	Reconditioning	Remanufacturing	Recycling	
	Provider	Customer / User	Others	
Responsibility for Production				
Initiating the Service				
Provide of Operating Personnel				
Provide of Service Personnel				
Property Rights Right to use th product				
Right to modify the product				
Right to earn income from product				
Right to sell the product				

Figure 8. PSS configurator (excerpt)

The first column (#1 in figure 8) lists the properties, whereas the following three columns contain a choice of values in the upper part of the configurator (#2) and role related properties in the lower part of the configurator (#3). A unique configuration is formed by the combination of one or more values per row for each property. The last column (#4) documents the impact of a defined characteristic on the components of the business model canvas, which is necessary to integrate the PSS configurator into the whole procedure. This last column gains special importance when an evaluation of alternative PSS scenarios is conducted, because a discussion about choice A or B always refers to the previously elaborated business model.

5 EVALUATION OF PROCEDURE AND METHODS

5.1 Explanatory example from the case study

The following example illustrates results that were achieved by deploying the before presented approach. This case was performed with the management board, product developers and a customer relationship manager of a company that offers augmented reality solutions to manufacturers in the automobile branch. The focused PSS offered by this company enables the customer to implement poka-yoke systems in assembly lines by projecting patterns and work instructions onto the work piece in the workers' field of vision. According to the described process the actual state of the company's business model was described and the key business processes were modeled with the PSS life-cycle, shown as excerpt in the following figure 9 on the left side "Actual state".

The excerpt of the actual state of the company in figure 9 already contains the results from the problem analysis. After distributing the system for projecting patterns of the part-positions and work instructions an adaption to the customers manufactured parts is necessary. This process is hardly economically scalable, which means that the "costs per customer serviced" will hardly decrease with an increasing number of customers. One solution for this problem was to transfer these activities (from provider to customer site) and introduce necessary supporting activities ("enable customer") as well as the supporting infrastructure ("Add-in for CAD-software"). This new configuration enables the same product functionality ("project part-position and instruction") but with a different PSS. In this specific scenario (1 of 3) an add-in for common CAD-software completes the product whereas the enabling of customers to acquire and process their data themselves changes the service-structure of the PSS. In the following step the typical PSS properties of this changed PSS were defined with the "PSS configurator" and, with each change, the impact on elements of the business model was documented and migrated to the business model canvas. In this case and scenario a software producer will become a new key partner and training the customers will become a key business process because it will become a well scalable part of the offering (e.g. through video-tutorials) and generate different revenue streams. The pricing model will focus more on licensing fees for the add-in and leasing fees for the product instead of selling the product and offer support for the individual use-cases of different customers. Finally, the strengths and weaknesses of each scenario's business model are the input for a SWOT-analysis and the deduced threats and opportunities represent a well comprehensible foundation for decision making.

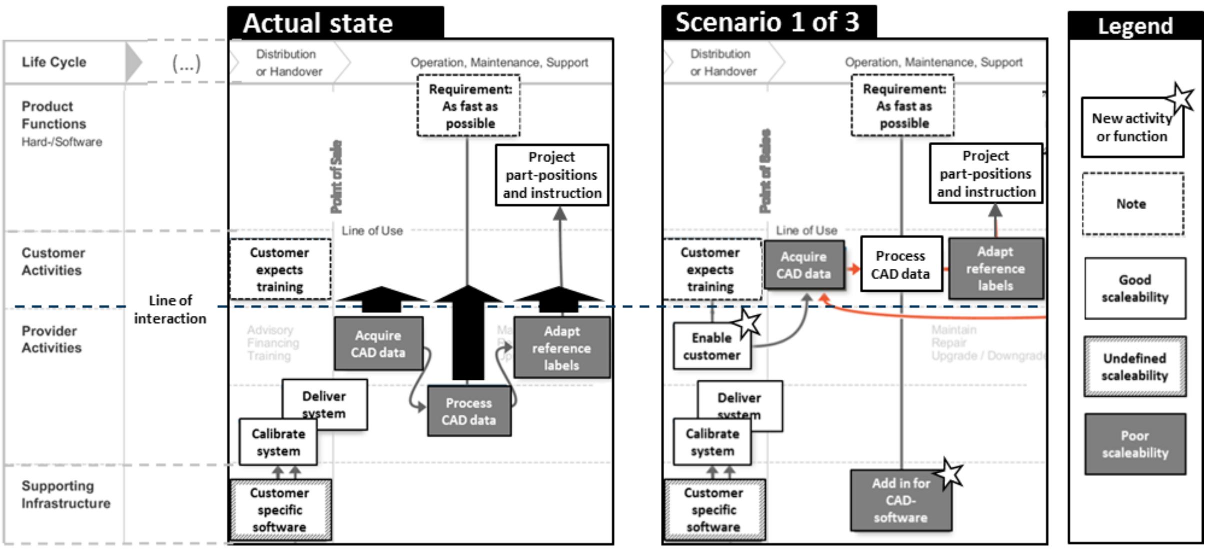


Figure 9. Example from case study, excerpt PSS life-cycle: actual state and scenario 1/3

5.2 Feedback and reflection

The feedback about the final version of the methods was that the moderator plays a valuable role to guide through the process of knowledge transfer and –documentation. Furthermore the procedure was described as a new, fast and constructive way to visualize and evaluate scenarios of PSS considering their individual business model and all phases of the life-cycle. This aspect was valued as most important because phases as "maintenance/support" and "phase out" are likely to be forgotten by product focused engineers.

6 CONCLUSION AND OUTLOOK

The procedure and the contained methods for modeling and evaluating PSS in the context of business planning were developed from state of the art methods in both disciplines, along the DRM. Through case studies the procedure could be improved and the influence on the product/service ratio was examined. As a result, it can be shown that the product/service ratio increases or declines depending on the initial objective definition, which is derived from the strategic objective of a given company. Hence, the usability of the procedure and included methods are validated through workshops and they can be used for individual strategic goals of arbitrary companies in the stage of strategic product planning.

From the authors perspective the presented procedure should be used to model the PSS of several companies with the same generic type of PSS (Tukker, 2004), e.g. 'leasing', in order to discover patterns in the PSS life-cycle and -configurator that describe best practices.

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