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Abstract. This paper explains the first steps of a smart PSS engineering approach, aimed at eliciting stakeholder needs, prototyping the value proposition, representing how the Original Equipment Manufacturer (OEM) will capture value and share it with a collaborative network of stakeholders while identifying and prioritizing risks from the value proposition. The approach addresses two gaps in the field of smart PSS design: (i) the need of visualizing solutions to support the transformation of value propositions for the stakeholders into a contract mechanism supporting value capture by the offering company and (ii) the importance of integrating risk management during the design of Smart PSS value proposition

Keywords: Smart PSS, PSS design, Value Proposition, Risk review.

1 Introduction and Scientific Positioning

Long-term strategies of manufacturing companies are dependent on their adoption of new Business Models (BM). The commoditization of products and digital development have posed an opportunity for manufacturing companies to transform their current business models into a digital service-oriented business model, in which value-in-use plays a major role. Since value proposition describes the benefits that customers can expect from the solution proposed by a firm [1], a clear design of this proposition seems vital to its market success. However, the formulation of a new value proposition implies several challenges. Among others, a large number of collaborative stakeholders, with distinct non-convergent needs and value expectations requires to be carefully considered during the whole process of solution design. Besides, a new value proposition may create value for several stakeholders (notably customers) but not necessarily generate value for the provider. In order to ensure the capture of value for the provider, a value proposition must be easily replicable in the form of a contract leading to a steady source of revenues. Therefore, design needs adapted mechanisms for economic value capture.

These challenges take special importance in the field of Product-Service Systems (PSS), particularly in 'Smart PSS' defined as "A digital-based ecosystem of value creation characterized by high complexity, dynamics and interconnectedness among stakeholders." [2]. *Value proposition representation* and *stakeholder mapping*, seen as key elements required to build a pertinent usual PSS solution [3], play an essential role in Smart PSS engineering. A well-defined value proposition is crucial to develop long-lasting relationships with users and its relevance should be maintained over time [4]. Although value-based guidance and evidence of risk-based decisions are highly advisable in the design of a complex system [5], scientific literature lacks guidelines on how to identify and evaluate risks during the phase of Smart PSS value proposition design. For a larger state-of-the-art in the field of value proposition design in PSS, the reader can refer to [6].

Aiming at increasing the industrial applicability of Smart PSS design, this research is developed as a collaborative work with the company Elm Leblanc. Thus, the paper deals with the operationalization of methods for smart PSS value proposition building. More precisely, this paper presents a value proposition design approach complementing current frameworks with the following two specific added values:

- The development of an iterative, multi-stakeholder value proposition building approach based on the mapping and visualization of the value creation for each involved stakeholder via a modelling and visualization tool (PS3M) to support the collaborative process [7].
- The inclusion of risk identification and evaluation in an early stage of the value proposition building processes, to mitigate and monitor them during the whole Smart PSS engineering process.

Thus, this paper presents a structured approach to assist Original Equipment Manufacturers (OEMs) in the definition of solution-oriented value propositions for smart PSS. This approach allows to (i) identify key stakeholders for the Smart PSS, (ii) collect key stakeholder needs, (iii) ideate functionalities to satisfy these needs, (iv) define alternative value propositions, (v) identify value capture mechanisms for the solution provider, and (vi) identify the key risks affecting the solution. A case study in the field of the thermo-technology industry (Elm Leblanc) illustrates the approach.

The structure of this paper is as follows. Section 2 describes the approach for designing and prototyping value propositions for Smart PSS. Section 3 illustrates the application to an industrial case. Finally, we present conclusions and perspectives.

2 Value Proposition Prototyping in Smart PSS Engineering

As collaborative research with Elm Leblanc, the authors propose to build the approach based on the scientific gaps already mentioned and the feedback from practitioners of Smart PSS engineering. This approach (Fig. 1) presented in this paper, provides an operational guide for the activities required for defining and prototyping the value proposition for a Smart PSS solution. This approach is part of an extended Smart PSS Engineering framework presented in [8]. This Smart PSS Engineering framework results from the study of PSS design literature, agile approaches for smart PSS, Value proposition design methods [1] [9], and Risk management [10]. Thus, the approach described below follows an iterative logic inspired by [5]. This logic facilitates to react to the different types of risks during the whole engineering process.

Fig. 1. Overall view of the prototyping approach.

This smart PSS value proposition design includes advances on the two gaps mentioned above, visualization and risks, within various engineering steps. The activities that contribute to risk identification along the whole approach are listed in Table. 1. These activities are associated with some of the framework stages presented in this paper. The identified risks are recorded in a *design risk register*, with their corresponding assessments of the probability of occurrence and potential impacts. The design team should come up with monitoring strategies to track the high-impact risks. A graphical decision-based computer tool, PS3M [7], allows capturing visually all useful elements and knowledge contributing to value proposition definition, supporting knowledge sharing among stakeholders along the design process. Hence, PS3M is used to represent graphically the components of the Smart PSS value proposition. It proposes a set of modelling views presenting complementary aspects of the ongoing value proposition, gathering a shared design knowledge base.

The '*Strategic contextualization*' step provides the initial inputs with the identification of key stakeholders, key risks, and a representation of an Ecosystem map within PS3M. This step will not be detailed here, since it is considered as an input of subsequent steps explained below.

Table 1. Activities contributing to risk identification during value proposition design

Stage of the approach	Activities for risk identification
Strategic contextualization	PEST and SWOT analyses, Ecosystem mapping
Collection of stakeholders' needs	Potential market estimation
Value proposition prototyping	Service catalog representation on PS3M, Value model proposition Model-Clash Spider Web [5]

2.1 Collection of Stakeholder Needs

After the '*Strategic contextualisation*' step, the challenges of design team are to create value in this existing ecosystem, then to estimate the potential market.

The *Collection of Value Expectations of Key Stakeholders* is made via Design Thinking [9], then integrated with both the visualization and risk approach proposed below. Contextual and in-depth interviews with the key stakeholders are necessary to elicit stakeholders' expectations and problems to be solved. The analysis of these interviews leads to the creation of customer profiles defined in terms of customer jobs, gains, and pains [1]. In addition, expectations are classified into five dimensions of value creation, providing a classification of value expectations to support value proposition building: economical, environmental, social, relational, and functional. These analyses help in understanding the different usage contexts linked to the expectations of each key stakeholder. Finally, current customer experiences are mapped as 'customer journeys' to highlight opportunities to improve the value-in-use experience. All these elements of information can be stored and shared within the design team through the PS3M Ecosystem map to ensure that the value proposition devised from expectations analysis will have high desirability.

The *Estimation of Value Potential for the OEM* is necessary to ensure the incorporation of the value proposition in a profitable business model. Overall estimation of the potential market becomes imperative before further developing the value proposition. This estimation is a qualitative characterization of the market into distinct customer classes together with a quantitative estimation of the market share in the short and middle term. PS3M proposes a specific 'Demand view' to visualize suitable markets along with potential customer classes with their associated use profiles in a shared project knowledge base. These potential market estimations are used as a source to identify risks affecting provider value capture: the risk register is updated.

2.2 Value Proposition Prototyping

Expectations identified in the previous step are a prior requirement for the ideation phase. Consequently, the design team must prioritize the jobs, pains, and gains of key stakeholders, considering their importance for each stakeholder [1]. Then, the ideation phase consists of a brainstorming session aimed at defining a general *value proposition statement*, and the functionalities that the solution will offer. These functionalities are captured and represented in the PS3M modeling tool via the combination of two views: the 'product view" depicts tangible and digital elements of the solution in terms of product options and the 'service view" contains intangible elements in terms of service packages. These representations ease risk identification based on of the capabilities required to deliver the services included in the value proposition. The *risk register* is updated accordingly.

The general value proposition statement has then to be refined to make explicit how physical, digital, and intangible elements generate value for the stakeholders. To support this activity, we propose the use of Value maps [1], which efficiency in Smart Services' design is proven: iteratively, a value map is developed for each key stakeholder separately, resulting in several alternative value propositions for each. These alternative value propositions are structured and formulated as 'service packages' targeted at different customer classes. Then, referring to all previous design knowledge already gathered, the design team defines decision criteria leading to choose the most appropriate value proposition for each key stakeholder, considering OEM's value expectations. At this point in the engineering process, validation of the chosen value propositions is conducted with OEM's internal actors that are in close contact with customers. This validation aims at examining the feasibility of the value proposition, from both a technical and market viability points of view.

Finally, the success conditions of key stakeholders are identified, then displayed in a diagram and registered in the PS3M tool. This representation allows identifying risks related to the potential incompatibilities amongst the success models of each key stakeholder [5], since neglecting them may lead to the failure of the system delivering the PSS solution. These risks are recorded in the Smart PSS design risk register.

2.4 Value Capture Mechanism Design

Designing a value proposition requires presenting evidence of the profitability and scalability of the economic model associated with the value proposition [1]. Since previous research has little addressed this aspect, either for traditional [11], or Smart PSS design [12, 13], it is important to define, at early stage design, the roles of the contract's owner, the revenue mechanism and the possible penalties when the expected functionalities and/or outcomes of the contract are badly delivered. A very clear definition of the contract helps to avoid any failure in value delivery [14].

In this step, the design team explores the different economic models associated with a Smart PSS value proposition, namely, product-oriented, use-oriented, and result-oriented. Aiming at addressing the gap mentioned in the previous paragraph, we propose to draft the Smart PSS contract via the PS3M's specific 'Offer view'. This representation aims at visualizing the alternative paths to deliver the Smart PSS solution, in commercial terms: (i) type of selling contracts, (ii) content of the contracts in terms of products, digital components, and services, (iii) demand forecasting, (iv) characteristics of the customers that are likely to sign the drafted contract. This representation leads to a first global definition of the cost and revenue structures associated with the Smart PSS value proposition.

2.5 Risk Review

The risk register contains the list of all risks identified and assessed through the process of design and prototyping of the value proposition. The classical stages of risk management, namely, identification, evaluation, and prioritization of risks are performed. If after having executed these stages, the OEM finds an acceptable level of risk, it will pursue the engineering process while monitoring and applying such mitigation strategies. On the contrary, if the OEM concludes that the risk level is too high, it will decide to reevaluate the value proposition, target another customer segment, or address other stakeholder jobs, pains, and gains, avoiding in this way to pursue efforts that might compromise the OEM's financial health.

3 Case Study

We illustrate the application of our value proposition prototyping framework via a deductive case study [15] starting from the evolution of a solution developed by a fabricant of gas boilers (the OEM) mainly addressed to social housing. The OEM also performs the maintenance of its products as part of its current service catalog. Converting the current product and service offering into a Smart PSS solution would enable the target customer and maintenance companies to monitor and operate a fleet of gas boilers. To assess the potential of this change, the proposed approach is applied by modelling suitable Smart PSS configurations using the PS3M toolkit: a focus group (design group) within the company was consulted and both primary and secondary data were collected and structured as follows.

3.1 Collection of Stakeholder Needs

Firstly, the design group elaborated a mapping of the current business ecosystem associated with the selling and maintenance of gas boilers, for the target customer. This mapping enabled the OEM to identify several key stakeholders, including end-users of the products, maintenance firms, and energy companies among others. Different risks were identified and recorded in a risk register. The design team identified the stages of the activity cycle of the target customer, namely configuration of the thermal system, installation, commissioning, operation, monitoring, maintenance, repair, and scraping. The OEM decided that the Smart PSS solution would be aimed at the operation and monitoring stage.

In-depth interviews were conducted with social landlords, tenants of the social housing units, and maintenance companies, with the objective to identify their needs. From the interviews' analysis, *customer personas* were created for end-users and maintenance staff personnel. Next, a list of customer jobs, pains, and gains are associated with each customer profile. These insights were categorized into value dimensions, e.g., unnecessary technical interventions impacting the monetary value dimension of the maintenance provider. Then, customer journeys were mapped based on the identified customer pains. These mappings were focused on depicting certain aspects of the user experience concerning the preventive and curative maintenance of the gas boilers, the gas boiler fleet management, the installation of the boiler, among others. The insights obtained with these mappings were used to formulate the potential functionalities of the Smart PSS solution. In parallel, an estimation of the potential market targeted at social landlords was conducted and then represented on the PS3M toolkit.

3.2 Value Proposition Prototyping

The needs of key stakeholders captured in the previous stage and expressed in user stories are used to carry out a creativity workshop. At the end of this workshop, the main functionality of the Smart PSS solution was defined, along with a catalog of services included in the solution. This catalog, modelled via PS3M, was used to identify risks concerning the deployment of the digital services. The most important risks associated with the deployment of these services concern data security, data storage, and data processing in real-time.

The design team linked gain creators and pain relievers to each of the envisioned services, by using PS3M (Fig. 2). Each of these services is related to the key stakeholders that will benefit from the service. Then, a discussion on the usage contexts of the solution helped to define service packages that addressed the different usage contexts of the customers, the social landlords, and the maintenance providers.

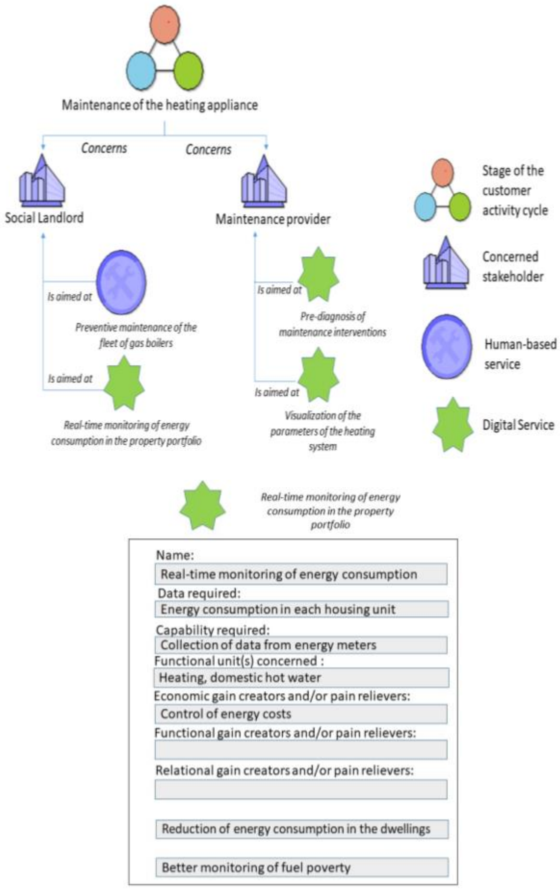

Fig. 2. Value proposition representation on PS3M.

3.3 Value Capture Mechanism

In order to structure the content and terms of the contract, the design team used the PS3M tool to represent visually the components of the contract. The design team decided to sell the hardware and to offer a service contract to either the maintenance provider or the social landlord. This service contract offers a range of smart services, namely, breakdown prediction, remote control of the fleet of gas boilers, energy consumption monitoring, and remote optimization of the settings of the thermal system. This visual representation triggered the discussion within the design about the conditions of the contract, such as the billing plan deadlines and the terms of payment.

3.4 Risk Review

Throughout this value proposition design process, the most important identified risk concerned the identification of the key stakeholders to commercialize the Smart PSS solution. A previous project of the OEM, related to a similar remote-monitoring solution, showed that assuming the wrong stakeholder as a client led to the commercial failure of the Smart PSS solution. In that case, the end-user of the boiler was defined as the client of the solution. However, end-users were not interested in acquiring a solution to identify breakdowns of the product, as they expected the product to work properly all the time: a specific manner to control such a risk had to be devised. Other key risks detected during the next steps of the engineering process dealt with data theft and potential external sabotage of the system.

4 Conclusions

This paper proposed a Value Proposition Prototyping approach aimed at assisting OEMs in the definition of digital service-oriented value propositions. The main contributions of the research dealt with the development of a multi-stakeholder collaborative prototyping approach based on a graphical modelling tool (PS3M) together with the inclusion of risk detection and review linked to value creation. A case study illustrates the approach and underlines the complexity of transforming a usual product-based business model into a smart PSS solution.

The application of the proposed methodology remains at a preliminary level and needs more in-depth developments but already shows the potential of the proposed approach. Further work is required to include a method to evaluate the value proposition(s) that results from the ideation and selection stages. A quantitative risk evaluation may be appropriate in this context. The approach proposed in this paper is expected to be applied in a case study targeted at the private housing market. This new case study involves the participation of a larger number of stakeholders.

Therefore, the complexity of the value proposition prototyping tasks increases, making it possible to test the capacity of this work to deal with higher complexity.

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