Decision-making process for Product Planning of Product-Service Systems

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Abstract

Due to the shift from products to services and the resulting gain of importance in planning product-service systems (PSS), a reliable decision process for the planning phase of PSS is essential. In this paper, we defined requirements for such a decision process by analyzing several decision processes for early stages of product and service development from literature. Interpreting their advantages and disadvantages reveals that none of the approaches fulfills all requirements needed for planning PSS. For this reason, we built a decision process by combining and extending existing elements of decision processes. The result is a process model, which facilitates to adapt requirements and characteristics several times. Unlike other approaches from literature, this process provides a higher customer integration, adaptable requirements list and it considers services, tangible products and PSS-infrastructure. To identify weaknesses and strengths of our decision process, we conducted a small case study. For this, a student team used this process for planning a rentable pedelec for tourists and commuters.

Keywords: Decision making; product-service-systems; planning process; customer integration

1. Introduction

One challenge for product development is the change from solely tangible products to more immaterial goods, such as services [1]. This requires offering more than just a product, but opens new business models on the other side. This deferral is called the product-to-service-shift [2]. Combining products and services to a product-service system (PSS) enable companies to better meet customers’ requirements, to increase customer connectivity and to focus on own core competencies [3]. Since developing PSS differs from developing stand-alone physical products or services (see section 3.1), the PSS-planning process has to be adjusted to the PSS-specific requirements for a planning process (see section 3.1). A PSS-planning process has to consider tangible components, service components, the merging infrastructure, the company’s knowledge and competencies, and external factors [4]. For planning and developing PSS, they have to orient to the customers and their needs. This makes it necessary to raise the level of customer integration in the early phases of PSS-development, compared to the level of customer integration the developing stand-alone physical products or services.

In this paper, we develop a decision-making process for planning PSS. This process model shall describe the required decisions, the relevant information and the needed people and stakeholders to belong from the idea of a PSS to the PSS-concept. This PSS-concept models the product and service components as well as the connecting infrastructure. It represents the start of the development, which concretes the PSS-concept. To build such a decision process, we analyzed existing planning processes covering different perspectives from literature. As none of the considered approach is suitable to our requirements of PSS-planning processes, we advanced the best suiting approach [5] by transferring elements from other approaches. A student team tested the resulting planning process for planning a pedelec.
2. Literature Review

For the literature review, we analyzed ten planning processes. We considered planning processes for PSS, for stand-alone physical products, and for stand-alone services. We analyzed the approaches in terms of how they facilitate to plan a customer-oriented PSS-concept. For this, we defined several criteria before the literature research:

The PSS-infrastructure enables the delivery of a PSS and includes its resources [6], like communication systems or energy supply. Planning the PSS-infrastructure has to be considered by our planning process (Infrastructure considered). Before building PSS-concepts, customers’ requirements have to be considered, because a PSS orients to the customers. Decisions about the business model (e.g., eight PSS-types according to [7]) and how the company wants to make profit (high price for physical product, low prices for services or low price for physical product and high prices for services) must be made before building PSS-concepts (Customer requirements before planning). To meet the customer-oriented character of PSS, a PSS-planning process requires integrating the customers (Customer integration). A market-conform PSS uses the strengths of the providing company compared to competitive companies and considers the market environment. To meet those market requirements, the PSS-planning process has to include a market analysis (Market analysis). We analyzed and evaluated the approaches according to the described criteria. Table 1 shows the results of the literature review. During the literature research, we extended the list of criteria and defined requirements for our PSS-planning process (see section 3.1).

2.1. Considered approaches from literature

The planning process in VDI 2220 [8] focuses on stand-alone products. While this approach considers intern and extern factors and provides a suitable structure for the planning process (requirements, product definition, planning-surveillance), it lacks in continuous integration of customer requirements. Furthermore, it includes only business areas that the company is equipped with competences in [9] and neglects other business areas.

Gausemeier et al. [10] developed a strategic product planning process which emphasizes the relevance of the strategy. However, this approach considers the planning process on an abstract level and does not include services and the PSS-infrastructure.

The planning process in [11] takes the level of products’ innovations into account and distinguishes between incremental and radical innovations. This approach does not consider services and has no option for customer integration and continuous adaption of requirements.

Van de Kar [12] designed his planning process mainly for services, the organizational infrastructure and technology architecture. This approach allows a high level of customer integration. However, the way of customer integration (e.g., meeting customers, testing phase at customers) makes huge efforts.

The approach of [13] is a planning process for products and services and includes the integration of physical product and service. However, this approach does not plan a PSS, it just combines product and service. A PSS is more than just the combination of a physical product and a service: As the physical product can only provided in combination with the service, both the physical product and the service have to be compatible to each other. Both types of components must have corresponding interfaces. This interlacing between physical product and service must be considered within the planning process, which is not provided by this approach [13].

Morelli [14] distinguishes between the solution space and the problem in his planning process. This process considers physical products as well as services. The late conduction of a market research and a lack of customer integration increase the probability of developing beyond the market.

The approach of Yang et al. [5] is a PSS-planning process, which allows changing the PSS-concept by iterations, if the concept does not meet the defined requirements. Even though the concepts are changeable, they do not consider adapting defined requirements during the planning process. Late adaptations of the concepts will be very expensive and affordable [15].

Tonelli et al. [16] developed an abstract procedure for defining PSS-strategies. They neglect the physical product part of the PSS and the connecting infrastructure. The planning process of [17] includes the physical product components, the service components, as well as the connecting infrastructure. They consider all relevant external factors, however the customer is just regarded at the beginning and not at evaluating PSS-concepts.

Geum & Park [18] developed an approach which integrates all relevant elements of a PSS. While they describe the PSS-elements on a detailed level, they keep the processual part too abstract. Furthermore, they do not integrate a suitable market research.

2.2. Conclusion

Table 1 shows the considered planning processes and how they fulfill the identified criteria (see section 2.0) We identified the planning process [5] as the most suitable approach for planning product-service systems: The abstraction level of process description of this approach is detailed enough to understand the whole planning process and abstract enough to apply this process to all kind of PSS. This planning process is a structured approach and it considers requirements from the very beginning and facilitates iterations. Despite those strengths, we identified several weaknesses of this approach: However, as the phase “concept development” only considers services, this approach focuses services more than tangible products. The planning process does not consider the connecting infrastructure and the strong customer integration is missing.

To eliminate those weaknesses, we included parts of other planning processes to optimize the approach of [5]. For this, we first defined requirements for our PSS-planning process, which are based on the evaluation criteria of section 2.
Table 1. Planning processes and criteria.

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3. Adapted PSS-Planning process

3.1. Requirements for the adapted PSS-planning process

Based on the criteria and the findings from the literature review, we defined requirements for our PSS-planning process:

- Uninterrupted documentation
- Strong contact to the customer
- Customer integration
- Identification of customer requirements for planning
- Adaptable requirements list
- Considering results from a market analysis
- Support for the selection of principal elements
- Considering tangible product and service elements
- Support for concept definition
- Evaluation of identified concepts
- Consideration of services associated to the product
- Planning PSS-infrastructure
- Consideration of scenarios and strategy
- Support for selection of the best suitable PSS-concept
- Deployment of a complete PSS-concept

The mentioned requirements describe the needs of a planning process for Product-Service Systems. Planning PSS is more than just adding services to an existing product: customer have to integrated, PSS-infrastructure has to be designed and the planning must fit to the strategic objectives.

The identified planning process [5] fulfills most of the requirements. However, the process shows a deficit in the following requirements: Requirements were only identified at the beginning and they were not adapted within the process (uninterrupted documentation, adaptable requirements list). Customers are only integrated at the beginning by the customers’ requirements; however, they are not directly integrated (strong contact to the customer, customer integration). The process focus on services neglects tangible product elements (considering tangible product and service elements). PSS-infrastructure is not mentioned (planning PSS-infrastructure). Insufficient integration of strategic objectives (consideration of scenarios and strategy).

3.2. Adapting the PSS-planning process

To better fulfill the identified requirements for the process [5], we used elements from other approaches and integrated them into the approach of [5]. To change the focus on only service to tangible products, we used the consideration of tangible products from the approaches [8] and [13]. We integrated a planning of the infrastructure as in [12] to ensure the supply of all needed services. To provide a future-proofed PSS, we considered future scenarios in our approach as mentioned in [14] and [17]. For the phase “concept evaluation” of approach [5], we added another decision point. This enables iterations to the beginning of concept evaluation, which is not provided by [5]. In our approach, requirements are checked in each review point and not only at the end of concept evaluation. This reduces the range and time of iterations or changes and weak or critical points are identified earlier in the planning process. This is assisted by a strong integration of the costumers as mentioned by [12].

3.3. Resulting PSS-planning process at a glance

The mentioned adjustments result in an adapted planning process for product-service systems (Fig. 1). To include customer needs over the entire planning phase, product planners should identify and refresh customer requirements several times and not only once at the beginning. Requirements may change over time. Some characteristics wished at the beginning of the planning process may become unimportant to the costumer at the end of it. On the other side, it is possible that new technologies may rise in other fields, which could also influence the requirements of costumers. Our approach enabled repeatedly regarding the customer requirements by iterations in the planning stage in different steps and levels.

In addition to the customer survey, a market analysis compares competitors and generates new ideas or trends in market, which customers did not know yet. After acquiring this information, we define a decision point before the planning process will be continued. This decision point covers go/no-go decision with experts not only from product planning but also from different fields and customers. This decision point will be described in more detail in the next section. Participating persons might not agree about the status of the concept, because essential information is missing. This makes an iteration of the first step necessary. If all involved persons agree on the concept, the first step, which we call “requirements” is successfully accomplished. The second step “concept development” addresses the development of new concepts based on information collected in the previous step. In this step, tangible parts of product-service system are first identified based on involving the customer. Furthermore, product related
accessory services have to be identified, which are needed for the major elements.

The next step plans offering and delivering of the products and services to the customer. The last step in the phase considers future and usage scenarios. At the end of this phase, another decision point occurs: Concepts are proofed whether they fulfill defined requirements. If essential requirements are not met by at least one concept, or if additional requirements emerged from the last phase, the last step is repeated.

After accomplishing this decision point, the last phase starts, which we call “concept evaluation”. This phase evaluates the concepts according to the requirements and extracts the most suitable one. This step has to involve the customer as well. The last decision point finalizes this step.

If problems or differences occur, they are solved by iterations and stepping back to prior phases. An iteration might also require to switch to the first phase, when new requirements appeared. After solving all ambiguities and agreeing on the decision, the best fitting concept is selected for realization.

3.4. Review points in the planning process

Because of the special requirements of product-service systems and the need for an adapted decision process, decisions itself have to follow an adapted decision process as well. We built this decision process based on the special needs of product-service systems. As mentioned above it is essential to include customers in this decisions.

The first decision point’s target is to ensure that all relevant information and requirements are recorded. It mainly focuses on customer requirements, information out of the market and the state of the art. Testing identified requirements and collected information achieve that target: Available information must be able to answer all questions regardless of the level of detail. If this fails, additional information have to be collected. Fig. 2 shows the decision process used to achieve this target. Defined requirements and gathered information about customer wishes, the market and influences are input for this decision process. The decision checks whether the amount and level of detail of the collected information are adequate enough to make a decision with less uncertainties. If not, an iteration in the previous step of collecting information is necessary to increase the security of the decision, later. If so, decision-makers test requirements regarding to the feasibility and necessity. This step is necessary, to hold the amount of information at a low level. Unrealistic requirements are eliminated to handle this information properly. Accordingly, requirements might be adapted or collecting more information might be necessary, too. Unneeded requirements will be faded out.

This step concentrates on the main requirements and reduces the amount of information. The next step identifies obvious negative interdependencies, in order to adapt requirements, which interfere in a negative way at the very beginning. The result is an agreement of requirements, which flows into the development process.

The second decision process, shown in Fig. 3, reviews the concepts of the second phase. The set of agreed requirements defined at the end of R1-Review and the developed concepts are the input for this decision process. The decision checks whether those two input-elements are overlapping each other.

This results either in an adaption of the requirements, the concepts or in a need for more information. Every requirement has to be fulfilled by at least one concept. Reflecting the overlap of requirements and concepts is needed for the evaluation of the concepts in the next step of the planning process: The evaluation will only guarantee robust results when all requirements are covered. At the end of the phase “concept
development”, repeating this phase will be easy, if one requirement is not fulfilled by a concept. The last decision process, shown in Fig. 4, considers all evaluated concepts. This is essential to guarantee providing the best fitting concept for one customer. In the first step of this decision process, it is important to understand the gap between best-fitting and not best-fitting.

![Decision process for R3-review](Image)

Consequently, the concept with the smallest gap is the best one for the individual costumer. All concepts are considered ones again. This reproduces the decisions made. If any discrepancies are detected, they are reflected ones again to ensure the correctness of the decision. This is the main target of this decision point.

The following step confirms this claim. Hereby, it is appropriate to include all available information. The requirements or the concept’s characteristics might also be changed or adapted if discrepancies occurred. The last step is the final agreement on a PSS, which will be delivered to the costumer.

4. Case Study

The decision process was evaluated by a case study, the planning of PSSycle. The PSSycle is a pedelec to rent especially for tourists and commuters and was designed by a team of students at Technische Universität München. In addition to the pedelec, services like maintenance and repair are offered. As the focus of this project was on customers and their requirements a need for a high customer integration, especially in the decision process emerged. To reduce the amount of information to be considered, we applied our planning process only at the electrical energy supply.

The first review was settled after all requirements were ascertained and defined. The first step ensured the accuracy of the level of detail. As the knowledge of the EN15194, which is relevant for pedelecs, was not available, additional information was gathered. Findings from ergonomics have to be considered in order to state the exact dimensions of the pedelec. This includes maximum allowable forces, inertias and masses. The requirement “charging a smartphone on the ride” was lacking of information and caused a further research. After that, the team tested the feasibility and necessity of all requirements. They identified the requirement “charging the on-board computer by riding the bike” as not necessary and eliminated this requirement.

A matrix for comparing requirements to each other revealed negative interdependencies (Fig. 5). The team discussed the identified negative interdependencies but they did not value one of them as critical enough to eliminate a requirement. Even though consideration did not change the PSS-concept itself, it made the team aware of potential critical points. Those points and requirements were regarded in the development with special attention, which reduced the criticality of those interdependencies. In next step, the team developed different concepts, in order to meet the defined requirements.

![Negative interdependencies between requirements](Image)

After developing concepts to fulfill the defined requirements the R2-Review is made. The main target of the R2-Review is to ensure the overlap to the requirements with at least one concept. For this, the concepts were linked to the defined requirements. This showed that all requirements were met by several concepts and no further action is necessary. The coverage was ensured and the concepts are ready for evaluation in the next step.

The complete concept fulfilling all requirements was identified. The R3-Review ensured that this concept is most suitable to the requirements: All reasons for the excluding of all other concepts were repeated and discussed. This enabled the team to reflect the decision, why this concept is the most suitable one. This step was repeated for all defined requirements. After confirmation, no other requirements appeared. Therefore the identified concept was presented to a small group of potential customers. They finally agreed on the concept and the planning process was finished successfully.

5. Conclusion

The main target was to create a new decision process specialized for product-service systems by comparing and adapting different planning processes to a new one. In this
section, we mention the assets and drawbacks of the new decision process and possible fields of usage.

The product planning concerns multiple factors and parameters. This leads to a great quantity of information, which is difficult to manage. Planning a PSS rises this quantity of information compared to a mere product. To handle this great amount of information, we developed this planning process. This planning process includes three decision points and uses the information gathered before each decision point. This reduces the information considered in the decision to a manageable amount. Therefore, iterations are possible in the decision processes for collecting additional information. Another advantage is that requirements can be changed during the planning process. If customer change their opinion regarding requirements, requirements might be eliminated or adapted. The focus on the customer requirements in our approach leads to more reliable and customer oriented decisions. However, an extended integration of customers might lead to an extended amount and effort in communications: Many opinions have to be considered and every participating person has to be asked. Identifying obvious negative interdependencies as well as ensuring the coverage of requirements by concepts are beneficial parts of our approach to reduce uncertainty.

To ensure that a suitable concept of the PSS will be passed on to the realization, the last step of the last decision point is a final agreement on the product-service-system. Again, the high customer integration is a success factor in this step. Nevertheless it is important for a company to take their own interests into account. The PSS must fit to the culture of the company. This might be a problem of this decision process, which focuses too much on the customer. Another benefit is the systematic structure of the processes, which consist of small steps. Additionally, the findings from the previous planning phases were considered ones again in the decision process. This reflects the whole proceeding and reveals uncertain requirements. The recurring reflection in each decision point increases the reliability of the decision.

This approach supports PSS-provider to plan a suitable PSS. The benefits of all analyzed planning processes were combined and lead to an adapted planning process for product-service systems. Using this process and the decision points together enables reasonable planning of product-service systems.

In order to increase the reliability of this planning and decision processes a next step could be a further investigation and validation of these processes within different fields of technology. This research would help to understand where lack of the planning process might be, and which additional factors have to be taken into account to increase the reliability and usability of this process.

Acknowledgements

We thank the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG) for funding this project as part of the collaborative research centre ‘Sonderforschungsbereich 768 – Managing cycles in innovation process – Integrated development of product-service-systems based on technical products’.

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