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Product-Service Systems across Life Cycle

A Task Management Method for Product Service Systems Design

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Abstract

Product service systems (PSS), which generate higher value by integrating physical products and services, have attracted much attention in the manufacturing industry. To design a PSS, initiating companies need to explore various PSS options at the conceptual design stage. However, our PSS design workshops have revealed that traditional product-selling manufacturers rarely include PSS options because a PSS, which includes many service elements, is far from their traditional business. This study proposes a task management framework that enables manufacturers to develop various PSS options from their product-selling business. The proposed framework provides designers with viewpoints and checklists for a PSS design. The effectiveness of the framework is demonstrated through an example case.

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Keywords: Product Service Systems; Business Model; Design Experiment; Task Management

1. Introduction

With economic globalization, many companies are struggling to make a profit because of the competition in their business. Manufacturers are finding it difficult to increase their profit by selling just products because many companies lower their prices by using cheaper labor [1]. To generate a higher sustainable profit, product service systems (PSS) have begun to attract attention as an option for income generation. In general, a PSS is a business concept characterized by the integration of products and services.

To design a general PSS business model, initiating companies need to select an appropriate PSS by exploring various PSS options at the conceptual design stage. However, PSS design workshops, which the authors have conducted many times, have revealed that few manufacturers can do this because traditional manufacturers are required to change their mindset for more service-oriented one. This is difficult for designers from traditional manufacturing industries because PSS options are far from their daily scope of business. To generate various PSS options, therefore, manufacturers have to gradually develop PSS options from a product-oriented to service-oriented focus through PSS design.

This paper proposes a task management framework for PSS development for manufactures to generate multiple PSS options. The framework summarizes the tasks that PSS planners need to perform when generating various PSS options. We also provide guidance on how to manage discussions for generating PSS options.

2. Existing Studies

2.1. Classification of PSS

PSS is a broad concept, and thus several concepts have been proposed [2-4]. Tukker classified PSS as shown in Figure 1.

A product-oriented PSS is a business model that mainly focuses on service products, such as maintenance or consultancy. This type of business provides services aimed at

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supporting part of a customer's activities within the product's lifecycle. A use-oriented PSS is a business model that focuses equally on both product and service, such as product sharing or rentals. In this type of business, the provider owns the product and offers customers the right to use it. A result-oriented PSS is a business model that mainly focuses on a service with the product, such as Power by the hour@Rolls-Royce [6]. In this type of business, before service offering, providers and receivers first contract a Service Level Agreement that states customer requirements. The providers then use any means to satisfy the customer's requirements. Specifically, a PSS is a type of business model that aims to fulfill higher customer requirements by combining products and services.

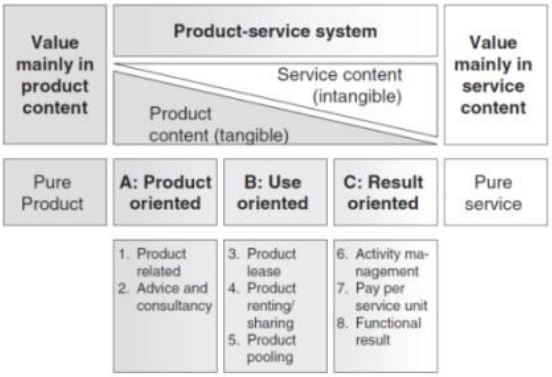

Figure 1 Classification of a business model for product service systems [5]

2.2. PSS design methods

A number of researchers have proposed a design method for a PSS business model. Based on business model domains, Ostaeyen proposed a method for PSS option generation [7]. Meier developed a PSS resource planning method by using heuristic optimization [8]. Rese proposed an ontology-based PSS business model design method [9], and Wiesner proposed a strategy for designing a PSS business model using a business model canvas [10].

Despite the many PSS business model design methods, a design method for transiting PSS business model classification, as shown in Figure 1, is rare. It is therefore difficult for manufactures to transition from selling products to offering PSS based on the classification.

3. Research Methodology

This study aims to develop a method that helps manufacturers generate multiple PSS options. To this end, the authors have conducted PSS design workshops many times and have analyzed the trend of each outcome for the workshops. For example, to identify the characteristics of a PSS design solution and its design process, Tanaka et al. proposed a design process analysis method for PSS design [11]. This study revealed the important design operations that lead to the characteristic changes of the PSS design process. Specifically, in order for manufactures to generate a service-oriented design solution, a stepwise discussion of the manufacturer's existing business is effective. Manufactures should discuss the product-oriented PSS, then the use-oriented PSS, and finally the result-oriented PSS. The present study develops a framework to contrive multiple PSS options starting from the manufacturer's existing business.

To develop the framework, we apply a framework proposed by Barquet et al. [12]. On this framework, Barquet et al organized the characteristics of PSS according to three types of PSS shown in Figure 1. Developing the process for this framework took place in two steps. First, we analyzed the protocol data obtained from PSS design workshops conducted so far. Here, we divided the protocol data in three according to PSS classification shown in Figure 1 by using framework proposed by Barquet et al. Specifically, we related protocol data and characteristics of PSS solutions such as Advise and consultancy for a product-oriented PSS, Product lease for a use-oriented PSS, and Functional Result for result-oriented PSS. Second, we identified the following key design operations: a) Key design operations that generate a use-oriented PSS from a product-oriented PSS, b) Key design operations that generate a result-oriented PSS from a use-oriented PSS. To determine such design operations, we classified the three-divided protocol data by using the KJ method [13]. Thus, we organized the identified key design operations as checklists for a PSS design.

4. Task Management Method for PSS Design

4.1. Outline

To gradually generate multiple PSS options, this paper proposes two types of framework: a) an analysis tool for a PSS business model from a product-oriented PSS to a use-oriented PSS; b) an analysis tool for a PSS business model from a use-oriented PSS to a result-oriented PSS. Each tool consists of four design viewpoints and some checklists. The viewpoints are "Business Concept," "Business Process," "Requirements," and "Advantages and Disadvantages for the Alliance." The checklists contain the criteria needed to achieve each viewpoint.

4.2. PSS design framework for supporting ideation from a product-oriented PSS to a use-oriented PSS

- Business Concept (from a product-oriented PSS to a use-oriented PSS)

To design a product-oriented PSS and a use-oriented PSS, designers first define the services to be added to the core product of the PSS. Designers then need to allocate resources for the PSS offered to stakeholders. Thus, for the Business Concept, designers clarify the ideal PSS business model that the owner wants to realize. For example, designers plan a business concept based on the owner's, partners', and customer company information, such as company size, the offered products and services, and core competency. Information about target end users, such as age, preference, hobby, and life style, is also useful for business concept planning.

- Business Process (from a product-oriented PSS to a use-oriented PSS)

To find opportunities for value proposition in a PSS, designers first focus on the product-use phase and all activities related to product use. The use-oriented PSS requires more resources compared with the product-oriented PSS because a use-oriented PSS provides rights to product use, such as renting or sharing. A PSS complements resources by building multiple stakeholder alliances. Thus, in the Business Process, designers identify all the activities related to their own core products. For example, if your company is an Information and Communications technology (ICT) provider specializing in system development planning, then requirement definition, design, development, testing, implementation, operation, and management are such activities. Designers then need to identify methods that realize the value for each activity. To do so, designers determine the business activities that partners can support in their own companies' business process. Moreover, designers should clarify the roles that both their own company and partners have when forming an alliance. To do so, designers explore not only asking partners to support their own companies' business process but also actually supporting their partners' business process.

- Requirements (from a product-oriented PSS to a use-oriented PSS)

Since a PSS is a business model of collaboration with multiple stakeholders, designers need to clarify all stakeholder requirements. Thus, designers explore each requirement from the perspective of their own company and that of partners. Further, to form an alliance, designers need to design a beneficial relationship for all stakeholders. Designers must clarify the considerations for forming an alliance, such as offering products and their ownership and business operational risks.

- Advantages and Disadvantages for the Alliance (from a product-oriented PSS to a use-oriented PSS)

Designers should explore not only their own benefits but also the benefits to partner. Thus, designers explore each advantage and disadvantage from the perspective of their own company, partners, and end users. For example, based on customer product-use activities clarified in the Business Process, designers explore advantages and disadvantages by supporting or replacing their partners' business processes.

4.3. PSS design framework for supporting ideation from a use-oriented PSS to a result-oriented PSS

- Business Concept (from a use-oriented PSS to a result-oriented PSS)

The result-oriented PSS is different from other PSSs in terms of performance; PSS providers and receivers agree the service level before the service offering, and the providers satisfy the service level by any means. Thus, in the Business Concept designers clarify the ideal "performance-based" PSS business model that their own company wants to realize. Further, in the result-oriented PSS, a company may have a new role that exceeds the existing scope of its business. Hence, if stakeholders play new roles in the PSS, designers should plan a business concept that enables stakeholders to expand through the operation of the business.

- Business Process (from a use-oriented PSS to a result-oriented PSS)

As mentioned previously, service providers need to satisfy their customer requirements by any means. Hence, the result-oriented PSS has a greater degree of freedom because the service provider does not have to follow the existing business model. Thus, in the Business Process, designers explore the possibility of supporting or replacing a partner's business process beyond its existing business model.

- Requirements (from a use-oriented PSS to a result-oriented PSS)

With regard to the result-oriented PSS, designers carefully need to explore customer requirements for defining the appropriate service level. Thus, designers understand customer value by considering end users, which may influence customer value. Designers explore requirements from the perspectives of their own company, partners, and end users. Here, designers define performance level based on the differences in end user characteristics between partners and temporal requirement change. In addition, to provide a result-oriented PSS, service providers should increase their responsibility according to the degree of freedom. Thus, designers need to explore future risks and solution plans before providing service.

- Advantages and Disadvantages for the Alliance (from a use-oriented PSS to a result-oriented PSS)

To operate a PSS sustainably, designers should explore their own benefits along with partners' and end-users' benefits. In particular, the result-oriented PSS is a business model that is characterized by a long-term contract with particular partners. Hence, designers should examine the advantages and disadvantages for the business operation. Further, if their own company plays a new role that exceeds the existing scope of their business, designers should explore not only existing end users but also potential end users.

4.4. How to use the framework

Designers first explore the product-oriented PSS by referring to their own existing business. Here, designers generate a use-oriented PSS by discussing all the checklists for the frameworks, as shown in Table 1 (Appendix). Then, designers manage the design tasks by using the checklists. Designers manage the progress by separating the checklists into one that has been achieved and one that has not been achieved. Once all the checklists have been achieved, designers generate a result-oriented PSS from the use-oriented PSS by discussing all the checklists in the frameworks, as shown in Table 2 (Appendix).

5. Application

To verify the proposed framework to enable designers to generate multiple PSS options, we applied the proposed framework to an actual PSS design workshop. This workshop was held as a lecture for graduate students of Tokyo Metropolitan University. The theme of this workshop was "Service Added Condominium for the Elderly." We divided

the examinees into three groups and gave each group company roles. We set aged residents as the common end user of the three groups. Figure 2 shows the stakeholders in this workshop.

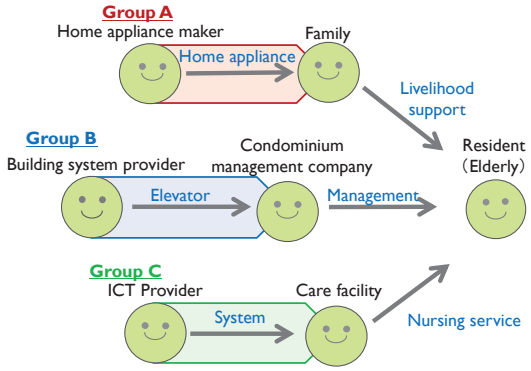

Figure 2 Stakeholders in the PSS design workshops

The verification process was as follows: First, examinees generated PSS options by brainstorming. Examinees then reviewed their PSS options based on the proposed framework. For evaluating characteristics of generated PSS design solutions, we used the framework proposed by Barquet et al (mentioned before). Specifically, we associated each generated design solutions with PSS classified as three types on Barquet's framework. Thus, we evaluated the effectiveness of the proposed framework by comparing two PSS options (before and after). Table 3 (Appendix) shows the PSS options generated by brainstorming, while Table 4 (Appendix) shows the PSS options generated by using the proposed framework. A summary of the characteristics of the brainstorming results is presented below.

Through the brainstorming, the ICT provider generated "shopping attendant support service for the elderly" as their business concept. This PSS option is regarded as a value proposition of a use-oriented PSS (see Table 3) because the Business Concept is focused on value generated at the product-use phase. Thus, for efficient resource procurement, the ICT provider asked a home appliance maker to outsource wheel chair development. This PSS option is regarded as a key partnership of a product-oriented PSS (see Table 3) because the ICT provider asked its partner to support or replace its own business process.

On the other hand, with proposed framework, the ICT provider contrived joint development for the wheelchairs. This PSS option is regarded as Key Partnerships of a Result-oriented PSS (see Table 4) because this business concept was performance-based with regard to development cost. Specifically, ICT provider took some responsibility for wheelchair development cost by contracting the number and sales channels of wheelchair. This PSS option is regarded as Cost Structure of a result-oriented PSS (see Table 4).

Summarizing the above, one of the main differences between the brainstorming results and the results from the proposed framework was that the"*ICT provider joins home appliance development by investing a part of the development cost rather than outsourcing.*"

6. Discussion

We compared the PSS concept generated by brainstorming with the PSS concept generated by using our proposed framework. Whereas the PSS concept generated by brainstorming included the characteristics of a product-oriented PSS or a use-oriented PSS, the PSS concept generated by using our proposed framework included the characteristics of a use-oriented PSS or a result-oriented PSS.

Before using the proposed framework, the cost structure was not reviewed (Table 3). Thus, designers discussed partners' advantages for an alliance by referring to the checklist record "Advantages and disadvantages for an alliance have been clarified" (Table 1). As a result, the ICT provider decided to collaboratively develop home appliances by taking on part of the development cost. Further, in order for the home appliance maker to profit, ICT providers defined a number of sales and sales channels (Table 2). From this result, the proposed framework supported designers by providing discussion issues.

In future work we need to conduct a workshop for practitioners in manufacturing and verify the effectiveness of the proposed framework using other examinees. Further, the proposed framework was developed with data obtained from successful workshops that the authors have conducted, and these data could have influenced the experimental environment. Therefore, we should verify our results by conducting workshops under different conditions.

7. Conclusion

In order for manufactures to generate multiple PSS options at the conceptual design stage, we proposed a task management framework. Specifically, we analyzed protocol data from PSS design workshops and developed a stepwise framework to generate a result-oriented PSS. Future work includes verification of the proposed framework.

Table 1 Analysis tool for a PSS business model

From a product-oriented PSS to a use-oriented PSS	
Business Concept ☐ Based on both owner and partner company information, feasible alliance plans were conceptualized	*Requirements* ☐ Products and services that owner company provides to stakeholders have been identified ☐ Products and services that partner company provides to stakeholders have been identified ☐ Ownership of offered products and services has been investigated ☐ Alliance risks have been considered ☐ A solution for alliance risks has been discussed ☐ For forming an alliance, a standard based on a minimum of stakeholders' demands has been established ☐ Operational costs for alliance business have been discussed
Business Process ☐ Own business process has been outlined ☐ For forming the alliance, roles of partner companies have been identified ☐ For forming the alliance, roles of owner company have been identified ☐ Own business process that partner companies can support (or replace) has been identified ☐ Own company supports (or replaces) the business process of the partner company has been considered	*Advantages and Disadvantages for the Alliance* ☐ End users have been discussed in addition to both owner and partner companies ☐ Alliance business has been discussed from a viewpoint of end user usability ☐ Advantages and disadvantages for an alliance have been clarified (for owner company, partners, and end users) ☐ Continuity of alliance business has been predicted from the viewpoint of the product lifecycle

Table 2 Analysis tool for a PSS business model

From a use-oriented PSS to a result-oriented PSS	
Business Concept ☐ Performance-based alliance plans have been conceptualized based on both owner and partner company information ☐ An alliance plan that enables stakeholders to expand through the business operation has been proposed	*Requirements* ☐ Products and services have been identified from the viewpoint of each end-user's characteristics ☐ The possibility of end users' required value might change has been discussed ☐ The performance level— stakeholders' need to be satisfied during the alliance—has been clarified ☐ Future risks caused by a performance-based process have been anticipated ☐ A solution plan addressing new risks caused by a performance-based process has been discussed ☐ For forming an alliance, the possibility that owner company might have a new role was discussed ☐ Own company has agreed that the new role would exceed its existing business
Business Process ☐ Business process of partner companies has been understood ☐ Based on partners' business process, the business process that owner company can replace has been identified	*Advantages and Disadvantages for the Alliance* ☐ The meaning for forming an alliance with a "particular" partner has been discussed ☐ Both merits and demerits for existing end users arising from the alliance have been clarified ☐ Potential end users have been discussed ☐ Both merits and demerits for potential end users arising from the alliance have been discussed ☐ Operation of the alliance business has been discussed from a long-term point of view ☐ Usability for the end users by forming a "performance-based" business has been discussed

Table 3 ICT provider's application results (brainstorming)

	Product-oriented PSS	Use-oriented PSS	Result-oriented PSS
Customer Segments		・Care facility that needs cheaper home appliances (ICT provider has ownership of a wheelchair)	
Value Propositions		・Shopping attendant support service with a wheelchair	
Channels			
Customer Relationship			
Revenue Streams		・Lease fee for a wheelchair	

Key Resources	・Sensing devices equipped with wheelchairs	・Management system for wheelchair-use information	
Key Activities		・Management of wheelchair's sharing use	
Key Partnerships	・Outsourcing of wheelchair development ・Support wheelchair development by providing data acquired from sensing devices with wheelchair （Activity for supporting outsourcing）		
Cost Structure			

Table 4 ICT provider's application results (applied proposed framework)

	Product-oriented PSS	Use-oriented PSS	Result-oriented PSS
Customer Segments		・Care facility that needs cheaper home appliances （ICT provider has ownership of the wheelchair）	
Value Propositions		・Shopping attendant support service with a wheelchair ・Human resource matching service for shopping attendant	
Channels			
Customer Relationship			
Revenue Streams		・Lease fee for a wheelchair	
Key Resources	・Sensing devices equipped with wheelchairs ・Human resource for shopping attendant	・Management system for wheelchair-use information ・Management system for human resource matching information	
Key Activities	・Acquire dispatch workers for shopping attendant services from Post-retirement human resource center （Human resource outsourcing）	・Acquire information about elevator use by end users from building system provider	・Support wheelchair development by providing wheelchair use information to home appliance maker
Key Partnerships			・Joint development of wheelchair with home appliances maker
Cost Structure			・Contract the number and sales channels for the wheelchair by calculating novel development costs and expected income

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