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Who realizes a PSS?: an organizational framework for PSS development

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Abstract

In manufacturing, Product-Service Systems (PSS) that create value by coupling a physical product and a service have been attracting attention. According to this background, many researchers have proposed PSS development methods that provide guidance on HOW TO realize a PSS. However, difficulties still remain with regard to constructing an organization for PSS development; i.e., answering the question, WHO realizes a PSS? In order to clarify problems with regard to constructing the organization, this paper proposes an organizational framework for PSS development. Based on this framework, this paper points out some research challenges with regard to constructing the organization for PSS development, and then, introducing the PSS development methods that can address these challenges.

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Keywords: Product-Service Systems; Organizational framework; Implementation

1. Introduction

At present, many companies are struggling to make a profit and to compete with other firms that sell the products of the same quality at lower prices. This is due to the cheaper labor that exists in certain countries. It is therefore becoming difficult for many manufacturers to increase their profits just by selling products [1]. Because of this predicament, Product-Service Systems (PSSs) [2-4] have begun to attract attention as an option for income generation.

Accordingly, many researchers have proposed PSS development methods that provide guidance on HOW TO realize a PSS. However, difficulties still remain with regard to constructing an organization for PSS development; i.e., answering the question, WHO realizes a PSS? In order to develop a PSS, manufacturing companies need to broaden their role, not just being conventional organizations that simply sell products [5]. This organizational change requires the involvement of new and varying types of stakeholders [3, 5-8]. A development process involving various stakeholders requires mutual understanding of their capabilities, operational procedures, cultures, and so on. As a result, constructing an organization for PSS development, rather than just product development, becomes more difficult. Therefore, the question of who realizes a PSS is crucial for manufacturing companies when managing the transition from selling products to offering PSSs.

In order to clarify problems with regard to constructing the organization, this paper proposes an organizational framework for PSS development. This framework is represented as a network of organizations and members with specific roles. Based on this framework, this paper points out some problems with regard to constructing the organization for PSS development, and then, introducing the PSS development methods that can solve each problem.

The rest of this paper consists of the followings. Chapter 2 introduces existing researches related with organizational changes required for PSS development. Chapter 3 explains the proposed framework for PSS development, and then, pointing out the research challenges with regard to constructing the

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organization. Chapter 4 reviews the PSS development methods that can address these challenges. Chapter 5 discusses the results and Section 7 concludes this paper.

2. Organizational changes required for PSS development

In order to realize a PSS, manufacturing companies need to change their organizational processes and capabilities [5]. Integrated product and service development procedures are required in order for value to be realized for the customer. Many researchers have therefore proposed processes for PSS development that differ from those for product development. For example, Aurich et al. offer guidance strategies for implementing a PSS, positing a design process in which manufacturing companies can integrate both product design and service design [9]. In order to execute and manage these processes, manufacturing companies need to reassess their organizational capabilities. For example, Karni et al. discuss the capabilities required for realizing a successful PSS, defining the factors that allow these capabilities to be achieved [10]. In this model, each factor contains levels that represent paths toward the implementation of a PSS.

Such organizational changes require the involvement of new and varied types of actors [3, 5-8]. This need for integration makes PSS development processes more difficult than product development procedures. To solve this problem, many researchers have sought to develop methods for building an actor network [6, 11-13]. For example, Meier et al. propose a typology for PSS network organization that consists of customer, provider, and supplier, and be used to build a new network organization concept for PSS delivery [6].

3. An organizational framework for PSS development

3.1. Methodology for building the framework

While such research into building an actor network provides useful insights into the process involved in PSS development, it focuses only on external perspectives. In order to realize a PSS, manufacturing companies need to change their organizational structures both internally and externally [5, 7]. With the aim of developing a holistic approach toward constructing an organization for PSS development, this paper proposes an organizational framework that consider both the internal and external perspectives. To do so, this paper first conducted literature review on PSS organization, and then, revealed key characteristics for internal and external perspectives. Based on these perspectives, the proposed framework was constructed.

3.2. Characteristics of the proposed organizational framework

Fig. 1 shows the proposed organizational framework for PSS development. In this framework, the organization that seeks to implement PSS development is represented from both the internal and external perspectives. Each of these perspectives demonstrates some of the key characteristics that emerged from the literature review on PSS organization. The internal aspect indicates the members that play essential roles in PSS development and the interactions required between them. Meanwhile, the external perspective shows the types of organizations that should be involved in PSS development and their necessary inter-relationships. The details of each perspective are as follows.

- Internal organization

In this framework, the internal organization consists of the three kinds of members: the planner, the designer and the operator. The planner defines the responsibilities of one's organization through interactions with relevant planners in other organizations. The designer determines the structure of a product or service. The operator provides a designed product or service to the customer.

The implementation of a PSS involves dynamic changes in terms of resources, market demands, and customer requirements, as well as the continuous need for improvements that arises from gained knowledge [14]. These changes have great influence on the process of designing and delivering a product or service. The planner therefore needs to have the adaptability to be able to cope with the changes and to facilitate the development process within the organization, in collaboration with the designer and the operator (Fig. 1 (a)).

In a PSS, providers offer various services where they conduct product related activities instead of the customer. As a result, optimization of the product and the service structure is required in order for efficiency to be achieved in these activities. Here, the designer needs to communicate with the planner, clarifying the overall responsibilities of the organization. In addition, the operator must be involved in the designing the product and the service so that the designer can consider the

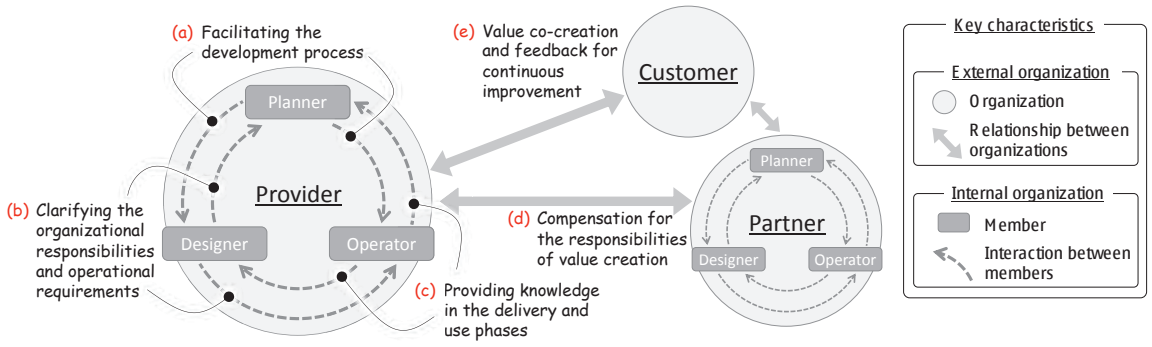

Fig. 1. An organizational framework for PSS development.

requirements for, and constraints within, the delivery phase [4] (Fig. 1 (b)).

During the delivery and use phases, the provider can gain various kinds of knowledge, for example, with regard to customer and product behavior. This knowledge can be used to redesign the product and the service structure, as well as for the reconstruction of the organization, this facilitating further PSS development [15]. Thus, PSS development does not end with the preparation of the product and the service; rather, it continues during the delivery and use phases [14]. For continuous development, the operator needs to obtain knowledge about the delivery and use phases, feeding it back to the planner and designer (Fig. 1 (c)).

- External organization

The framework consists of the three kinds of external organizations: the provider, the partner, and the customer. The provider corresponds to an organization that wishes to realize a PSS and to construct an organization for the PSS development, such as a manufacturing company. The partner supplies the components of the PSS, such as products and services, to the provider. The partner can also provide these components to the customer directly through collaboration with the provider. The customer is the receiver of the PSS. However, the customer not only receives the PSS but also works with the provider and the partner as a co-producer of value. Indeed, the relationships between the provider, the partner, and customer play an important role in the realization of high added value for the customer, which can enhance an organization's competitiveness.

In PSSs, providers need to offer an integrated product and service that achieves value in use for customers [2]. In this context, the partner relationship is considered to be a source of value [8]. From the viewpoint of value in use, the provider needs to manage the product through its lifecycle, as well as support the customer's activities in relation to the product and service [16]. In order to guarantee the availability of the product, for example, the provider needs to offer product-related services, such as installation and maintenance. In addition, it is also important to provide consultancy services to ensure that the customer is able to use the product efficiently. To compensate for such a broad range of responsibilities, it is necessary for the provider to collaborate with the partner(s) (Fig. 1 (d)).

The customer relationship plays a key role in the design of an effective PSS [17-19]. Early involvement with the customer is essential for the creation of a better solution that responds to the customer's requirements. It is also important for the provider to involve the customer in the delivery of PSS [18, 19]. Customers are regarded as co-producers in the value creation process in PSSs [20]. They play an important role in giving productive feedback, facilitating continuous improvement (Fig. 1 (e)).

In the development process, it is important to consider the changes that arise in terms of material/inventory flow, information flow, capacity, supply chain value, supply chain cost, and the relationships along a supply chain [21]. These changes can have a great influence upon an internal organization. Here, the planner needs to facilitate both the internal and external development processes; s/he is therefore responsible for begin the bridge between the internal and external stakeholders.

3.3. Research challenges for constructing PSS organization

Base on the proposed framework, as shown in Fig. 2, this clarified some problems with regards to constructing the organization for PSS development. The details of the problems are as follows.

RC1: Communicating with relevant stakeholders
RC2: Evaluating future prospects, such as demands and supply
RC3: Supporting co-creation with customers
RC4: Utilizing operator's knowledge in PSS design and operation

In the following chapter, this paper reviews the PSS development methods that can address these challenges.

4. Methods for An organizational framework for PSS development

4.1. Task management tool: PSS kernel (for RC1)

As mentioned in Chapter 3, the planner defines the responsibilities of the organization through interactions with the relevant planners in other organizations. In addition, the planner needs to facilitate the development process internally by collaborating with the designer and the operator. The planner therefore has to consider the development process holistically when managing tasks. S/he can then share information with the relevant stakeholders. In order to clarify such tasks within PSS development, the author of this paper proposes the PSS kernel

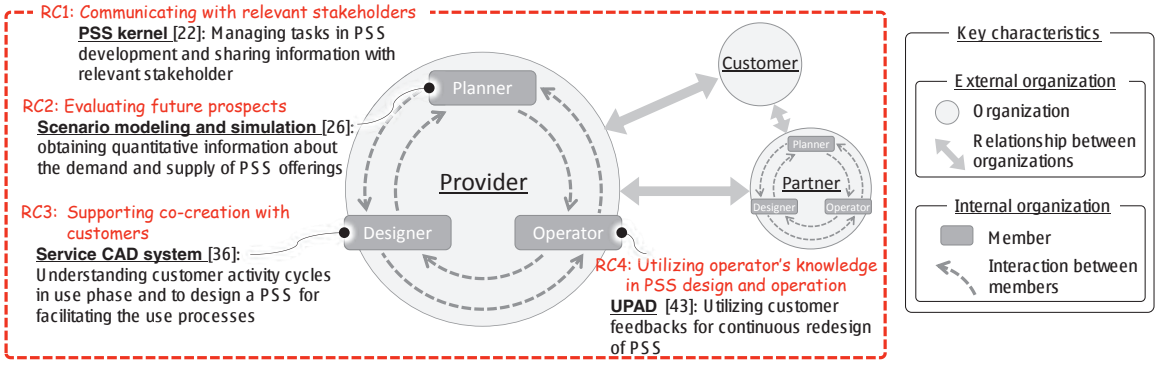

Fig. 2. Research challenges and PSS development methods.

[22] based on the concept of Software Engineering Methods and Theory (SEMAT) [23]. SEMAT is a practical software development framework that is aimed at redefining software engineering based on a solid theory, proven principles, and best practices [23].

The PSS kernel provides the essential elements for a PSS, as identified from the literature. In the same manner as the SEMAT, these elements are called Alphas, and express the viewpoints of those managing the PSS development process. The Alphas consists of Opportunity, Stakeholders, Requirements, Product-Service, Team, Work, and Way of Working. Each Alpha consists of a number of states that can be considered the criteria for assessing the development process. For example, the "Requirements" Alpha consists of six states: Conceived, Bounded, Coherent, Acceptable, Addressed, and Fulfilled. In each state, several items are defined to evaluate achievement of the state. For example, items for the state "Conceived" in the "Requirements" Alpha includes "Requirements and functions of the system have been clear," "Users have been identified," and "First capital investor have been identified." These Alphas and items have been defined based on the SEMAT; however, the Alpha "Products and Services" has been used instead of "Software System," as it suits our purposes better. Moreover, within this Alpha, the state "Actor Network Selected" has replaced "Architecture Selected" in the original SEMAT. Items for this state includes "Criteria for selecting actors agreed," "Actors identified," and "Plan for contracts defined." In addition, the state "Continuous Improvement" has been added instead of "Retire." Items for this state include "System for observing information about customers established," "Team for continuous improvement organized," and "Process for continuous improvement defined."

According to the features of the PSS kernel, we propose the use of a card set so that the planner can manage the PSS development process in a visible way. First, in order to grasp the current progress, the planner should check which items in each Alpha have been accomplished. Second, the planner should decide which of the unaccomplished items need to be accomplished in the next step. Finally, these items should be shared with the relevant stakeholders and action plans implemented for their achievement.

The PSS kernel cards enable the planner to view development holistically, and to make decisions regarding future tasks with relevant stakeholders.

4.2. Scenario modeling and simulation (for RC2)

Scenarios are used to describe the long-term development plans of governments and enterprises from diverse (e.g., financial, social, environmental, and technological) perspectives (e.g., [24]). Scenarios describe conclusions in the future and activities performed in order to reach the conclusions. They are developed with two different manners. By forecasting, possible conclusions are drawn with given activities, while necessary activities to reach given conclusions are identified by backcasting [25]. Scenarios provide quantitative information crucial in the early stage of PSS design [26]. With reference to the organizational framework for the design and implementation of PSS shown the previous section, this subsection describes (1) how the planners use scenarios to roughly quantify constraints on PSS derived from information gathered from the internal and external perspectives and (2) how modeling and simulation techniques are customized for PSS development based on scenarios.

First, scenarios are used as sources of the constraints on PSS in terms of the demand and supply of PSS offerings. In order to retrieve such constraints from scenarios, rigorous analysis on scenario description is crucial. For instance, the description in a scenario like "The amount of greenhouse gas (GHG) should be decreased by 80% in 2050 in developed countries" indicate the target property (i.e., GHG emissions) of specific members (i.e., developed countries) The description like "100 hydrogen stations are prepared before 2018 in Japan" indicates the capacity of service channels in a specific country. The term "the Base of Pyramid (BoP)" indicates the group of those who are characterized by their earnings and form a potential but large market of basic products and services. In the organizational framework, the planners are encouraged to obtain such information relevant to their PSS through communication with the operators, partners, and customers. The information is useful to roughly identify the demand and supply of PSS and strategically identify service contents delivered within the framework considering the quantity.

The planners still encounter difficulty in quantifying the demand and supply of PSS offerings and their long-term progress. The authors consider modeling and simulation techniques for PSS design are particularly suitable to refining and quantifying such information. These techniques studied in existing literature include system dynamics (e.g., [13]) and discrete event simulation (including life cycle simulation) [27,28]. These techniques have been mainly applied to the analysis of PSS in terms of the behavior of products (e.g., physical and functional deterioration from a life cycle perspective) and stakeholders (e.g., selection of contract types). With a system dynamics approach, parameters included in scenarios such as the population of a specific country are explicitly represented as simulation variables. With the discrete-event simulation approach, they are also computed by counting the number of instances (agents, entities) belonging to specific states. In order to effectively use these techniques for the scenario development by the planners, further study is necessary on simulation model representation compatible with scenario description as well as the format of statistical data (e.g., [29,30]) relevant to scenario description. Recent study on these study issues were presented in [26,31].

4.3. Design for use by designers (for RC3)

As described in Section 3.1, the viewpoint of value in use has assumed a significant role in PSS development. Service-dominant logic (S-D logic) (e.g., [20,32]) is concerned with the relationship between service and value in use. S-D logic has emerged as, arguably, the most important scholarly marketing debate in the last decade. S-D logic is also receiving increasing attention and interest in the CIRP community, and the subject is referred to in the CIRP Annals and CIRP Journal of Manufacturing Science and Technology articles (explained in [33]).

More to the point of designers' task in PSS development is

to fully understand customer activity cycles in use phase and to design a PSS for facilitating the use processes. Manufacturers need to go deeper into a holistic user experience in daily life in BtoC case and broader business activities of customers in BtoB case [34]. This use-centered viewpoint is quite a contrast with traditional engineering viewpoints in which we consider a product lifecycle consisting of sequential phases such as design, development, manufacturing, sales, use, maintenance, and disposal. Computerized tools for service blueprinting and/or customer journey mapping on service CAD system (e.g., [35]) are practical to analyse and design use processes.

The relationship between design and use has become a core issue in user-centered design approaches. The two must overlap, intertwine, and simultaneously change [36]. This implies a holistic view of design as tightly coupled with practical use that continues during in use phase [37]. S-D logic also considers value co-creation to be based on a customer's contribution to integrating proprietary knowledge and skills in service. An earlier study by the authors [38,39] suggested that an ecosystem consisting of different types of designs can link design and use. Design-of-use and design-in-use by the customer can function as a bridge between different types of value creation: providing value, adapting value, and co-creative value [40]. Design-from-use, which is amplified by accumulated use data, contributes to value co-creation for the manufacturer and the customer community.

4.4. Continuous redesign of service operations by service operators (for RC4)

The PSS providers are able to obtain customer feedbacks more frequently by making contact with customers through services. How to utilize these data for continuous redesign of PSS is one of the important issues in the proposed framework.

To adapt to these feedbacks and as a result to satisfy customer requirements, the role of service operators is becoming more important. Based on this background, the design methodology by service operators and the support technologies are being studied [41,42]. The necessity of service design by service operators is increasing in the pure service areas, recently. The increasing complexity of service operations and specialization of service operators make it difficult to understand the situations in service fields and how services are actually provided. The faster response to customer requirements is also required to be competitive in the market. Watanabe et al. proposed the design methodology named as UPAD [43]. This design process is being studied in the nursing-care services [44]. To enhance service operators' capabilities to understand the situations and share best practices, several design support tools have been also developed. For example, Nishimura et al. developed a communication support system to share the information on service fields and knowledge in operations [43]. This system was implemented in an actual nursing-care facility and care workers there are redesigning their service operations in their daily work [41]. In addition, the representation tool by service operators to develop mutual understanding on service situations and new service operations was also proposed and prototyped [44]. The application of these tools and methodology would be effective for PSS businesses.

The data collected in the delivery and use phase should be available for service planners and designers as shown in Fig. 1. Based on these data, the service planner can rearrange organizational structure to provide services and the service designer can modify the composition of products and services. For this purpose, the aforementioned design support tools are designed to collect the operation data. In addition, the database concept to collect and utilize these data is being studied, also [45].

5. Discussion

This organizational framework that has been proposed here for PSS development represents both internal and external perspectives. The external perspective includes the organizations that are essential for PSS development, as well as their relationships. The internal perspective, on the other hand, consists of members who play important roles, and their interactions with each other. In addition, the planner is defined as the member who takes responsibility for being the bridge between the internal and external organizations.

We assume that this framework would be useful for constructing an internal and external structure for PSS development. Especially, it enables PSS providers to determine the boundaries of development processes within one's organization. In addition, by looking at the interactions between internal and external members, the detailed processes of PSS development can be identified. It is then possible to identify who conducts these processes and to clarify the roles of the members.

Based on this framework, this paper has introduced PSS development methods to support each role (see Fig.2). The PSS kernel [22] enables the planner to consider the development process holistically when managing tasks. S/he can then share information with the relevant stakeholders. Scenario modeling and simulation [26] is useful for the planner to obtain quantitative information about the demand and supply of PSS offerings. Hara et al. proposed design methods, such as service CAD system [36], that enable the designer to understand customer activity cycles in use phase and to design a PSS for facilitating the use processes. Watanabe et al. proposed the design methodology by service operator, for example [42,43], that supports the operator to utilize customer feedbacks for continuous redesign of PSS. With reference to the framework, it is possible to identify who uses these methods, as well as which parts of the processes can be supported via holistic development approach.

As a future work, we plan to conduct a case study to validate the proposed framework. In addition, it is necessary to clarify the detailed processes within PSS development by considering the interactions among internal and external members in more detail. Other future plans include undertaking comprehensive reviews of PSS development methods. In each review, an existing method will be allocated to the proposed framework in order to identify the processes that are rarely supported by existing methods. Based on the results, the required methods for PSS development will be specified so that manufacturing companies can realize the transition from selling products to offering PSSs.

6. Conclusion

This paper has proposed an organizational framework for PSS development. This framework is useful for the construction of an organization for PSS development from both internal and external perspectives. Our future study includes specifying and concretizing more methods required for PSS development.

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