

Product-Service Systems across Life Cycle

A Framework to Design Integrated Product-Service Systems based on the Extended Functional Analysis Approach

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Abstract

Despite the growing research interest in PSS design and development methods in recent years, there is still no fully stabilized and shared understanding of the PSS design process. This can be partly explained by two main gaps: the decoupled design of product and services and the lack of operational solutions. This research aims at outlining the main characteristics of a proposal for a new PSS design framework, expected to contribute answering these 2 gaps. The proposition is based jointly on a recently created PSS design methodology and an extension of the functional analysis (FA) approach (NF X 50-100), which is commonly used in product design. The proposed framework intends to smoothly integrate the whole PSS design process, including product-service design and the network configuration.

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1. Introduction

The design of a PSS offer which maximizes the value for various stakeholders is a crucial stage to support the transformation of traditional manufacturing companies into integrated product-service providers. A successful PSS design relies on the integration of several dimensions such as product design, identification of service opportunities throughout the PSS life cycle and configuration of the PSS value network. To achieve these objectives, the notion of ‘services design’ must be incorporated into traditional approaches for product design [1], in order to create new offers which provide customers with the desired benefits via tailored products and services [2]. Although the quick increase of research interests in PSS design and development methods in recent years, it has been identified that the scientific understanding of the PSS design process both in the design community and in industries is still not fully mature. Several issues may hinder this scientific understanding, but this paper mainly puts forth the following ones. Firstly, an integrated design of product-service systems is not completely performed as services are mostly considered as add-ons to the product design. Secondly, existing PSS

design methods are short of operational solutions to ensure their easy implementation in industrial context.

This research is motivated by the two above mentioned gaps and aims at outlining the main characteristics of a proposal for new PSS design method. The proposition is based on the extension of the functional analysis (FA) approach (NF X 50-100), which is commonly used in product design, in order to make it applicable to PSS design due to its potential to support this specific design context. First, a literature review of existing methods dedicated to PSS design is presented in section 2 in order to clarify the gaps mentioned above. Moreover, the potentials of the traditional FA approach regarding the design of an integrated product-service system are identified. In section 3, the conceptual formulation of the new framework is presented by highlighting the interdependent activities necessary to deliver the PSS global offer requirements specifications. The paper ends with a discussion on the strengths and limits of the proposition regarding services ideas generation and value network configurations, during the early PSS design phases. Perspectives for the future work will be then drawn.

2. Research background

For helping manufacturing industries in their progressive mutation towards PSS offerings, any PSS project development team requires support in terms of design tools, techniques and methods [3]. The state-of-the art reveals that there are numerous methodologies developed to support the PSS design activities. Although their common intention to design integrated product and service systems which delivers value in use to the customer, it has been perceived that their visions were scattered in terms of scope and elements used to enhance the PSS design process. To illustrate this statement, some well-defined methods from the literature are described in the followings.

Alonso-Rasgado et al. [4] have developed the concept of ‘total care products’ consisting of architecture and business. Architecture refers to the physical product and the service support system (hardware) and the business refers to the market attributes. They proposed a fast-track design process, which breaks down the iterative process between the customer and supplier into distinct stages necessary for the creation of the ‘total care product’. In that way, the product functional specifications integrate the customer’s needs and they are simultaneously defined. Maussang et al. [5] targeted to provide engineering designers with technical product specifications linked with the whole system requirements as precisely as possible for the development of the physical object (O.P) and the related services units (U.S). They have exploited the functional analysis approach (NF X 50 100), where the graph of interactions (APTE ©) and the functional blocks are the elements used to bridge the gap between the system and the physical product. Shimomura et al. [6] have proposed an approach which aims at maximizing the service value for customers by extending the blueprint of a service offering in order to include information concerning the product and its service behavior. In terms of technique, a unified representation scheme of ‘human process’ and ‘physical process’ in the service activity/blueprint modelling is used. As a consequence, it is possible for service designers to model service activity while taking into consideration the customer value, the ‘human process’ (service function by human resource) and ‘physical process’ (service function by physical product). Based on industrial PSS projects, Medini and Boucher [7] have identified and analyze the ‘usage’ forms of each PSS offer in order to identify the value creation potential for the customer and stakeholders. They have characterized the customer’s categories, their needs, in terms of goods and services. Then, they cross these usages with the service opportunities for a PSS offer. Afterwards, the under designed PSS are formalized by a mean of progressive transformation of creative PSS ideas into well-defined scenarios for its delivery.

Regarding research contributions for PSS design, various design methods focus on designing the PSS network, for instance [7], [8], [9], [10], [11], [12], [13]. Other relevant design methods are based on the specification of product criteria to perform the PSS design, for instance [4], [5], [14]. Additionally, researchers such as Shimomura et al. [6], Sakao and Shimomura [15], Komoto and Tomiyama [16] and Hara et

al. [17] have proposed PSS design methodologies focused on services engineering. This underlines a large number of separate advances in this field. However, despite the spread of the PSS paradigm among academic and practitioners’ communities, several issues still hinder a common understanding of the PSS design process. As underlined by this small classification, PSS design approaches remains focusing on specific targets with a lack of real integration among these distinct objectives and advances. Each methodology puts forth a pre-eminent focus and point of view on design, and the models and design methods proposed are induced by this point of view.

To tackle this integration issue, Cavalieri and Pezzotta [18] have suggested a generic design process for PSS. However this is a state of the art, with a restrained objective to underline the main PSS design phases and to present perspectives of research, more than potential solutions. Besides, Kim et al [19] have studied the usability of various design support tools for PSS for each stage of the PSS design process. McAlone et al. [20] have also tried to promote integrated product/service thinking across organizational boundaries through a systematic approach for user-oriented product and service development. Although integrating products and services is discussed as a target in PSS design, there is a lack of clear formulation for each detailed step involved in this integration process. Thus, the question still arises about the real and timely consideration of both the product and the services specifications during the earlier stage of the PSS design. Lastly, there is a weak diffusion of such academic tools and methods at the level of industrial practitioners. Many PSS design methods are little oriented on operational solution and thus very little adopted in industrial context. Consequently, there is a need to clarify what form of approach can support an integrated design of a PSS global offer, while ensuring its real applicability in industrial context.

3. Proposition

3.1. Overview

For the proposition, it was decided not starting from scratch. Specifically, this research consists in transforming an existing methodology (Figure 1) dedicated to industrial PSS scenarios identification, modelling and evaluation [7], [21] into a complete PSS design framework. The whole will be structured within the functional analysis approach layout. To reach this objective, there is a need to integrate a specific design step named “design the PSS global offer” within this initial methodology in order to obtain a framework covering the full PSS design process. In this section, the initial framework dedicated to the design of PSS scenarios is first described, followed by an overview of the proposition. Then, the precise interrelations between the functional approach used in product engineering design and the PSS engineering design are studied, in order to demonstrate the potential extension of the functional analysis approach to support the full PSS design process. Moreover, it we highlight how to integrate the step “design the PSS global offer” within this initial framework in order to perform simultaneously the

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