

Product-Service Systems across Life Cycle

Open Innovation for ideating and designing new Product Service Systems

Eugenia Marilungo^{a*}, Eva Coscia^b, Angelo Quaglia^b, Margherita Peruzzini^c, Michele Germani^a

^a *Università Politecnica delle Marche, via Brecce Bianche - Monte Dago, Ancona (AN) 60131, Italy*

^b *Holonix, corso Italia, Meda (MI) 20821, Italy*

^c *Università di Modena e Reggio Emilia, via Vivarelli 10, Modena 41125, Italy*

* Corresponding author. Tel.: +39-071-220-4880; fax: +39-071-220-4708. E-mail address: e.marilungo@pm.univpm.it

Abstract

For modern manufacturing companies, the combination of physical products and intangible services (called Product-Service Systems or PSS) has been proved by time to be useful to enhance the product features by adding value throughout new functionalities, and bringing competitive advantages in a specific target market. Through PSS, companies create new business opportunities, extend the market share, differentiate the product portfolio, and improve sustainability. The PSS approach shifts the company attention from producing physical products to offering integrated systems. However, ideating and designing a PSS is a complex and multifaceted process, which requires multiple competences and cross-functions cooperation within the manufacturing company. In fact, the design phase requires to simultaneous deal with the characteristics of the physical product and of the intangible services, the last ones being by their nature fuzzy and difficult to define. Furthermore, the two entities have to be synergistically delivered and strategically managed thanks to the adoption of a PSS lifecycle management methodology and tools, in particular for the creation of a proper PSS infrastructure to delivery and maintain all the components from the design to the end of life phases. Several methodologies to design PSS can be found in literature. Most of them focus on technical development stages, while some of them face also the innovation aspects and sustainability. However, traditional product-centered approaches are not able to fully support the processes that manufacturing companies have to put in place for creating PSSs. This paper presents a new approach, based on the combination of the Open innovation method with IT solutions supporting information sharing and intra-team cooperation, in that any manufacturing company could adopt to manage the design process of a PSS. In particular, the methodology and the tools are focused on the early stages of the PSS design process, as Ideation and Concept definition that have been developed within the European FP7 project FLEXINET.

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Peer-review under responsibility of the scientific committee of the 8th Product-Service Systems across Life Cycle

Keywords: Product Service System (PSS); PSS Design; Product Service Lifecycle Management (PSLM); Open Innovation

1. Introduction

Currently Product-Service System (PSS) is a widespread trend consisting of adding services to the physical product in order to create new value for customers [1]. According to this definition, PSSs management represent the new challenge for the manufacturing domain. In fact, the design process is still structured for traditional products, even if recently several researchers have started to address the design of PSS as a whole. Several methodologies to design a PSS are explained in literature [2], and in some cases, they also achieved a preliminary industrial prototype [3]. However, industrial sector is still far from the adoption of PSS management solutions inside the companies, due to a scarce research,

development and improvement of the reference processes that support all the PSS design phases. In fact, the ideation and design processes for PSSs are complex and multifaceted, requiring multiple competences and cross-functions cooperation within the manufacturing company. Moreover, the strong interconnection between product and service along the PSS design process implies that they cannot be managed as independent entities, adopting Product Lifecycle Management (PLM) and Service Lifecycle Management (SLM) approaches separately. Therefore, any tool or application that monitors the evolution and the change of PSS offer, must provide a holistic approach able to manage their concurrent evolution. Analyzing the main phases of the

Products and Services lifecycles, it is possible to observe some commonalities and some differences harmonize.

This paper has the scope to show an innovative combination of methodology and IT tools able to offer a Product Service Lifecycle Management (PSLM) approach for collecting and managing information on Product and related Services along the PSS design process.

2. State of the art

2.1. Product Service System design and PSLM approach

When the concept of Product-Service System (PSS) is transferred into the business of industrial companies, it is necessary speak about the Servitization process. It is the mean to find new business opportunities by shifting the focus from offering physical, tangible products, towards offering customers intangible services that sometimes do not require customers to own the products, but just to use the services [4][5][6].

According to the Servitization process, the traditional product-centric companies can change their business, moving across different steps [7] until being more service-centric. This is probably the most innovative challenge that presently industries need to face. Indeed, the main difficulty is to combine the Product Lifecycle Management (PLM) jointly with the Service Lifecycle Management (SLM). In literature several authors have focused on such a topic, defining first of all the PLM and SLM models [8, 9, 10], and then proposing their interaction [11]. Normally, PLM solutions support manufacturing companies to manage the wide range of information related to the product, covering for example the markets, the customer requirements, the partners involved in the value chain, etc., covering only part of the whole lifecycle that is design and production. PLM originates from Product Data Management (PDM), which focused on design and engineering data. Recently new approached are merging, to extend the PLM focus to the whole lifecycle phases. Similarly, SLM systems supports data collection and management for design and engineering in a service-centered approach, as products are managed in a product-centered approach.

Stark proposed a product manufacturer's view of the lifecycle - described through the following phases: Imagine, Define, Realize, Support/Service, Retire [12] - that allows the distinction between product and service activities, but it does not cover the interactions between them.

The theory for the integration between the PLM and SLM needs to start from the definition of their mutual relations, as defined in the literature by [13]; they distinguished four alternative types of interactions between Product and Service Lifecycles may be:

- Service Lifecycle Management is triggered by the Product Lifecycle Management (SLM depends on PLM);
- Completely opposite to the previous case, the PLM happens accordingly to SLM (PLM depends on SLM);
- Product and Service are managed regularly. Mostly, the product and the related service lifecycle have the same length but their interactions happen when it is necessary;

- Both lifecycles are managed in a highly integrated way, so that the separating managerial boundaries between PLM and SLM disappear.

According to this context, the research work proposed in this paper uses a Product Service Lifecycle Management (PSLM) approach already defined by [14], which fits the third definition of PLM and SLM interaction, where Product and Service Lifecycles are managed together. Defining a new approach as PSLM to manage the integration of PLM and SLM in the aim of propose a PSS instead of traditional product, a new challenge is to identify the methods and tools able to support each phase inside the PSLM.

In literature, the most common methodologies able to approach the PSS design [15] are based on different approaches and theories:

- Business assessment and Value creation [16, 17];
- Functional modelling [18];
- Service Engineering [19, 20];
- Requirement Elicitation (RE), that is the main approach able to design a PSS, in order to identify the main requirements related to the market and customers to reach;
- PSS sustainability assessment [21];
- PSS validation [22].

In order to investigate the customer needs, RE proposes the adoption of the following approaches:

- multi-level analysis or the Design Structure Matrix (DSM), that can be used to define the main PSS functions;
- Business Use Case (BUC) analysis, which defines the use-case model and a goal-oriented set of interactions between external actors and the system under consideration [15];
- Serious Games to elicit PSS requirements and investigate the PSS lifecycle [23];
- Quality Functional Deployment (QFD) technique [14] that allows mapping the customer needs with the PSS functions to elicit the final PSS requirements for the solution to be developed by the correlation by means of a sequence of Houses of Quality (HoQ).

Research results pay more attention to PSS design and development methodologies rather than validating the PSS during the design phase; this implies to have a first PSS prototype only at the end of Product Service System design process which means that if the testing is negative, it is necessary restart the PSS design process from the beginning.

This paper aims to define a method able to manage the PSLM according to the third alternative proposed by [13], where also the Open Innovation approach is involved.

2.2. Open Innovation approaches

Due to the huge advancements in the fields of electronics and the deployments of communication systems, mobile devices and ubiquitous services able to provide anytime-anywhere connectivity to the users, spread rapidly over the past decade. This trend today is seen like an opportunity to interlink the physical world with the cyber world [24], leading to the emergence of Cyber-Physical Systems (CPS) [25][26]. The peculiarity of CPS is that the ICT system is designed together with the physical components to maximize the overall efficiency, thus being in contrast with classic

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