Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 59 (2017) 220 – 226

www.elsevier.com/locate/procedia

The 5th International Conference on Through-life Engineering Services (TESConf 2016)

An Integrated Collaborative Platform for managing Product-Service across their Life Cycle

Markos Matsas, George Pintzos, Anna Kapnia, Dimitris Mourtzis*

Laboratory for Manufacturing Systems and Automation, Dept. of Mechanical Engineering and Aeronautics, University of Patras, Patras, 26500 Greece

* Corresponding author. Tel.: +30-2610-997262; fax: +30-2610-997744. *E-mail address:* mourtzis@lms.mech.upatras.gr

Abstract

Product-Service System (PSS) design methodologies have been extensively researched during the past years. Various tools and methods have been established for the incorporation of sustainability and system-oriented lifecycle thinking in the design of PSS. This paper presents an integrated collaborative platform that aspires to conceptualize a new landscape of modular product-services that will be tracked throughout their lifecycle using a network of smart sensors enabling the extraction of useful value. The concept is based on a series of distinct components supported by a common semantic knowledge base, enabling the seamless collaboration of partners of multiple disciplines for the realization of product-services. Moreover, a set of services are used, which are integrated with the sensor network to return information about the performance of the PSS to the customers and the product designer, supporting them in the decision making process. Finally, an application of the proposed methodology in an industrial scenario is presented.

Peer-review under responsibility of the scientific committee of the The 5th International Conference on Through-life Engineering Services (TESConf 2016)

Keywords: Product Service System, Sensory System, Smart Monitoring, Feedback Integration

1. Introduction

Over the last years, sustainability has become one of the key success factors in a new product launch, bringing up the importance of incorporating relevant aspects in the early design phase of products [1]. The reduction of product's environmental impact and the consideration of the whole product lifecycle, being two major sustainability aspects have been lately included in numerous service-related product development concepts [2]. Furthermore, the increased importance of the service sector in industrialized countries has led many manufacturing industries to shift from product- to a service-based economy paradigm [3]. To this end, integrated product-service offerings have emerged, allowing the creation of innovative business models as an effort to increase the competitiveness and subsequently the revenue of industries. The benefits of shifting from products to Product-Service Systems can be also seen by the definition given by Mont. In [4] she defined the Product Service System as a system of products, services, supporting networks and infrastructure that is designed to be competitive, to satisfy customer needs and to have a lower environmental impact than traditional business models This recently emerged concept has forced industries to focus more on the creation of added value from services, bringing into view user-driven business models that incorporate sustainability characteristics in holistic design approaches [5]. The integration of technical support and the provision of industrial services along the entire lifecycle of products are also key points for the viability of industrial product-service offerings [6].

As a result of the so-called servitization of products, the influence, the characteristics of products and services have each other, has grown rapidly, introducing challenges to manufacturing industry beyond the traditional product development and engineering, which are currently not addressed by products and systems. Most of the products in today's market lack of the capability for efficiently adapting to customers' needs, while a limited amount of integrated methods exists for the holistic acquisition and processing of feedback information emanating from product-services by using the concept of performance indicators. The adaptation to customer needs, measured by customer satisfaction indicators, is a characteristic that can be traced to two major factors at the origin of a product: its design and manufacture [7]. Therefore,

Peer-review under responsibility of the scientific committee of the The 5th International Conference on Through-life Engineering Services (TESConf 2016)
doi:10.1016/j.procir.2016.09.009

the adoption of innovative producer-customer relationships is the key to the success of product-service systems design environments.

Addressing the aforementioned issues related to product-services, this paper represents a framework that supports the PSS design, development and evaluation phases. Specific focus is given to KPIs as the main components of the evaluation procedure. Furthermore, a KPI ontology is proposed so as to support the design process.

The remainder of the paper is organised as follows; Section 2 provides a review regarding the design and development methods of PSS that exist in literature. Section 3 presents the proposed framework, its component and the role of the KPIs. Then the use case is described in Section 4. Finally, concluding remarks and future challenged are provided in Section 5.

2. Design and Development of Product-Service systems

The design and development processes of products and services is characterized by a high degree of complexity due to their highly inventive nature. For reducing this complexity several process models have been established supporting developers with recommendations and practical actions. Whereas in classical product development several de facto standards have emerged such, process models for integrated Product-Service system development became a matter of research many years ago [8]. Integrated Product-Service System engineering methods will ensure that the service components will be fully compatible with the product ones. No matter which dimension is more important, product dimension or service dimension, a generic design approach should be capable of handling equally both of them [9]. The evolving process models build on established basic principles of both product development and service engineering and enhance them with Product-Service system-specific characteristics and requirements. The most prominent requirements dedicated to integrated development models are (i) when developing Product-Service systems, product and services are to be handled equally; (ii) to ensure the customer's acceptance, suitable methods of customer requirements management are to be taken into account.

Process models focusing on the design and production of Product-Services systems are provided by [9], [10] and [11]. The process models consider the specific characteristics of Product-Service systems. As characteristics are defined the offerings of a PSS to the customer. In particular, they adjust their efforts to the needs and desires of the customer who is considered as a central element in the provision of Product Service systems. Therefore, there is the customer integration feature in the Table 1 which indicates the customer value that is taken into account during the designing phase of a PSS. Through the analysis performed in Table 1, and following the Collaborative development feature, it is evident that the majority of the existing models neglect the collaborative aspects of the development process.

What is more, environmental aspects which refer to the sustainability factors, that are taken into consideration during the development phase, are also neglected.

Table 1: Consideration of aspects in recent PSS process models

	[17]	[9]	[18]	[19]	[20]	[10]	[11]	[21]	[16]	ICP4Life Platform
Specific Characteristics of PSS	●	●	●	●	●	●	●	●	●	●
Customer Integration	●	●	●	●	●	●	●	◖	◖	●
Collaborative development	○	○	◖	○	○	◖	○	●	●	●
Specific methods	◖	○	○	○	○	◖	○	◖	●	◖
Non-hierarchical networks	○	○	○	○	○	○	○	○	○	○
Environmental aspects	○	○	○	○	○	○	○	○	◖	◖
ICT-systems support	○	○	○	○	○	○	○	○	○	●
Meta-Products integration	○	○	○	○	○	○	○	○	○	●

●Yes ○No ◖Yes but not completely

Another deduction that resulted from the Table 1 was that there is a lack of Information and Communications Technology (ICT) in the product-service. A key drawback of the proposed technologies is the lack of integration of heterogeneous data sources by applying of existing standards, which is the core of a possible solution for the integrated design of products and services [12], [13], [14]. Although significant research work has been performed regarding this subject as well as the development of tools or techniques for integrating the databases of different stakeholders [15], it is focused either on manufacturing enterprises or service providers. Finally, another main drawback of current approaches is the management of Product-Services as an amalgamated product from their conceptual design phase, thus reducing the chance of future integrations through Meta Products, i.e. evolving products, which was not in any of the papers in the Table 1. This is evident even in approaches such as [16] where a three-step module partition process of an integrated Product-Service is presented. This method presents a modular design of the Product-Service, which however is targeting a specific Product-Service.

2.1. Feedback integration

Lifecycle strategies have received increased attention from modern design methods as approaches to accelerate the sustainable value creation through exploiting data from the entire lifecycle of the product [22]. Lifecycle feedback deals with returning usage information of products and services back into the value creation processes of the providers [23]. Going beyond traditional requirements management, feedback management may be sub-divided into product-focused feedback management and user-focused feedback management.

Product-focused feedback has been dealt in many research approaches. The main latest research outcomes focus on the product usage phase for returning product state information to ICT systems and the status tracking of products, especially using condition monitoring [24]. The use of an information feedback assistant agent as a part of a knowledge-based