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Aggregation of solutions for Functional Product life cycle: review of results from the Faste Laboratory

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Abstract

Functional Product (FP) can be viewed as a business concept which is aimed at offering a function or performance to customer on an agreed upon level of availability and cost as well as at providing incitements towards a sustainable growth. The development and operation of FP is a multidisciplinary and complex process. To support such process often advanced and creative solutions are required. Based on analysis of research conducted in the Faste Laboratory, this paper aggregates FP solutions consisting of existing methods, tools and models. Further, utilisation of FP solutions is discussed from the FP life cycle perspective.

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Keywords: solutions; Functional Product; life cycle; design methods; tools; models; development; operation; aggregation

1. Introduction

Functional Product (FP) can be viewed as a business concept which is aimed at offering a function or performance to customer on an agreed upon level of availability and cost as well as at providing incitements towards a sustainable growth. Among many global corporations there is an increased interest in using the FP business model for transition from selling product and service or a combination of products and service towards sustainable function/performance-based offerings [1].

In the existing literature there are various related to FP business concepts, e.g., servitization [2], Product-Service Systems (PSS) [3], Industrial Product-Service Systems (IPS2) [4] and Functional Sales (FS) [5]. Many of these concepts are developed in order to better fulfil customer's expectations and requirements by delivering an added value to customers through integrating products (e.g., hardware, physical artefacts) and services into a single offer. Products and services should in this context be designed to be integrated, and not just packaged or loosely bundled together [6]. Consequently, a design space of such business concepts will be enhanced and advanced.

In line with Alonso-Rasdago et al. [7], Lindström et al. [8] conclude that the FP development and operation is a multidisciplinary and complex process. This, since in order to have the necessary skills, competencies and capabilities to develop and operate advanced offers such as FP there is often a need to build regional or global FP consortiums. Lindström et al. [1] states that *"the surrounding environment can be multi-facetted and interorganisational with many partners, sub-contractors, suppliers and customers" (p.288).* Besides the fact that the FP provider consortiums are formed to link competences and capabilities, risks and revenue are also shared among the consortium partners [1].

The enabling main FP constituents are hardware (HW), software (SW), service support system (SSS) and management of operation (MO) [1]. All four main constituents shall be developed coupled and in parallel (concurrently) as well as operated in a coordinated way by the FP consortium during the entire FP life cycle. Since, the ownership of the FP (constituents) is foreseen to remain at the FP provider [1].

Last but not least, the FP life cycle consists of economic and technical life cycles. The FP technical life cycle is sub divided

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into HW, SW, SSS and MO sub life cycles in development and operation phases, while the economic life cycle is governed by a sustainable win-win situation between the FP provider and the customer [9].

Thus, to support the FP development and operation which include, for example, a proper coordination between four coupled and parallel development processes of HW, SW, SSS and MO as well as maintaining a suitable cooperation between multiple partners, one or more design methods are required [8], creative design is essential as well as creative thinking.

This paper concerns research work conducted in the Faste Laboratory, which is a VINNOVA Excellence Center for innovation in the area of FP. The following research questions were posed in order to guide the research:

- What FP solutions have been developed in the Faste Laboratory?
- In which phase of the FP lice cycle can the identified FP solutions be used?

The paper aims at aggregating solutions which are developed in the Faste Laboratory to be utilised in the FP life cycle. The term "solution" is used as an umbrella for existing design methods, tools, and models developed in an FP context.

2. Methodology

To achieve the desired aim and answer the research questions posed, a literature review analysis was chosen as a research method. The scope of the literature review was limited to the research work conducted in the Faste Laboratory.

The Faste Laboratory was founded in 2007 with 10 years primary operation time with a total budget of approximately 25M euro. Currently, around 30 researchers are employed within 5 various research subjects at Luleå University of Technology. The research activities within the Faste Laboratory span through diverse research areas such as gender and diversity development, knowledge sharing, simulation-driven design (SDD), distributed collaborative engineering (DCE), functional product development process (FPDP), and functional product business development (FPBD).

The Faste Laboratory currently collaborates with 6 industrial partners which are global manufacturing corporations in Sweden, involving around 50 industrial representatives.

The research results presented in this paper is a mixture of qualitative and quantitative nature. For the initial literature review a list of 281 Faste Laboratory publications was compiled. This list consists of theses, conference and journal articles as well as various other publications like books chapters and technical reports, written both in Swedish and English from 2007 to mid-2014.

The data collection process was based on the assessment of the Faste Laboratory internal reports, where various publications have been tracked. It is of importance to note that the reports are not available for public outside of the Fast Laboratory due to confidentiality issues. However, the authors of this paper are actively involved in the Center, therefore had full access to the reports. The list of 281 publications used for the initial review can be obtained through the authors upon request.

During the follow up review, certain criteria for publication selection were used: (i) only full journal or conference articles, (ii) entirely funded through the Faste Laboratory. As a results, 118 publications were chosen for further analysis. This means that theses, other publications and publications which have been just partly funded through the Faste Laboratory were excluded.

For data display and further data analysis, a matrix [10] and open coding technique were used [11]. The matrix includes the list of 118 references which have been divided into journal and conference publications and a short description of main results from each references.

As a part of open coding data analysis, all 118 references have been analysed and categorized into 7 groups. In overall, the process of categorization has been mainly based on the competence areas of the Faste Laboratory.

Accordingly, these 7 groups consists of 5 groups (including 66 references) with prescriptive FP solutions (i.e. simulation and simulation-driven design methods/tools, availability models) which are intended to be utilised in the FP life cycle and 2 groups (including 52 references) which are mainly descriptive and focused on building up FP theory (i.e. business and development process related theoretical frameworks and guidelines) and exploring gender equality and diversity issues in the FP context.

3. Results

3.1. Developed ideas for Functional Product lifecycle definition

The initial lifecycle model for FP was proposed by Brännstrom et al. [12]. The model involves three parallel and coupled development processes of the following constituents: hardware (HW), software (SW) and services. Each of the development processes, includes close interaction between each member of the development team or consortium, which in synergy is aimed at providing the customer with the desired function.

Later, Lindström et al. [1] suggested that the FP development process can be seen as parallel and coupled development of four main constituents which are HW, SW, service support system (SSS) and management of operation (MO). The SSS includes maintenance of hardware, decision-making, operations planning, remanufacturing, and education [7]. The MO includes matters of responsibility, risk management, transfer of intellectual property, building up trust and relations, availability management, cost drivers, revenue, etc. [1]. Also, the MO is viewed as a holistic constituent which ensures that HW, SW and SSS and their sub constituents are operational in a long term perspective [13].

Furthermore, it has been suggested that the FP life cycle includes technical and economic life cycles [9]. The FP