

The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems

## Design for Customization: A New Paradigm for Product-Service System Development

Amal Elgammal<sup>a,\*</sup>, Mike Papazoglou<sup>b</sup>, Bernd Krämer<sup>a</sup>, Carmen Constantinescu<sup>c</sup><sup>a</sup>Scientific Academy for Service Technology e.V. (ServTech), Bürgerstr. 54a, Hagen D-58097, Germany<sup>b</sup>European Research Institute in Service Science (ERISS), Tilburg University, Tilburg 5000 LE, Netherlands<sup>c</sup>Fraunhofer Institute for Industrial Engineering, FhG-IAO, Stuttgart, Nobelstraße 12, Germany\* Corresponding author (Faculty of Computers & Information, Cairo University). Tel.: +201094488895. E-mail address: [a.elgammal@fci-cu.edu.eg](mailto:a.elgammal@fci-cu.edu.eg)

### Abstract

In the traditional software development cycle, requirements gathering is considered the most critical phase. Getting the requirements right first time has become a dogma in software engineering because the correction of erroneous or incomplete requirements in later software development phases becomes overly expensive. For product-service systems (PSS), this dogma and standard requirements engineering (RE) approaches are not appropriate because classical RE is considered concluded, once a product service is delivered. For PSS it is impossible to foresee all future context conditions and customization needs customers may come up with after product deployment. In addition, the services supporting a complex hardware-software product depend on the individual product configuration a customer requires. For example, when a standard laser machine is equipped with one or more special sensors, new services may be needed that depend on sensor data from these new sources combined with other data generated by the standard machine configuration. Thus, we claim that RE needs to be extended to the deployment phase of a product and an agile approach is required to cope with emerging hardware and software requirements as a PSS is marketed. In this paper, a novel view-based model-driven engineering approach is proposed that enables collaborative product-service design and customization and copes with evolving, incomplete and unforeseen requirements. A prototype has been implemented as a Proof-of-Concept (PoC) and is currently validated on four industrial pilot cases as part of the H2020 project ICP4Life.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license

[\(http://creativecommons.org/licenses/by-nc-nd/4.0/\)](http://creativecommons.org/licenses/by-nc-nd/4.0/).

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.

**Keywords:** Mass Customization; model-driven Engineering; Domain Specific Language (DSL); View-based Modelling; Agile Product Service (PS) development.

### 1. Introduction

Mass production mainly involves the production of large amounts of standardized products, where customers have no longer the ability to individualize or influence the composition of the end product [1-3]. Product customisation recently became an emerging business need as companies began to recognise the great importance and benefits of delivering individualized customized products, while retaining the advantages of the mass production method. By having a greater focus on customers, companies can use this strategic opportunity to gain a competitive advantage and achieve a noticeable economic value [2, 4]. In their desire to become customer-driven, many companies have resorted to inventing

new programs and procedures to meet every customer's request. But as customers and their needs grow increasingly diverse, such an approach adds unnecessary cost and complexity to operations. As a result, companies have embraced mass customization in an attempt to avoid those pitfalls [5].

Product design seen from a perspective that combines products with its corresponding services is often termed Product/Service Systems (PSS) [6]. In PSS a product corresponding service is regarded as conventional service activity (e.g., maintenance, repair) that is coupled with a physical product to meet customer requirements.

Currently, PSS are facing severe drawbacks. The most notable drawbacks are that PSS are prominently conceptual

taking a marketing or business perspective and lacking a concrete IT implementation. PSS do not accommodate evolving user preferences or product differentiation features. Current PSS are unable to cope with multiple stakeholder views and automatically tailor product design to a customer's needs in real-time. They also neglect the collaborative aspects of the product design and development process. More importantly, PSS cannot provide a holistic view of products associating product structure with product quality. They do not support the composition/substitution of product-parts into the design of a coherent final product, and do not support analysis of product-related data gathered along product lifecycles – which remains totally unexplored - to improve data-driven decision making.

Mass customization (MC) refers to the combination of mass production and the capability to offer customized products. For any successful implementation of mass customization, a *product customizer* is a core software component, where a *model* describing the desired product must be defined and implemented employing the product customizer functionality. Product models must be developed collaboratively to describe an intended physical artefact (product-service) that is usually incomplete in the form of partial models that can be completed by the interaction with user groups and different stakeholders.

This paper proposes a novel formal view-based model-driven engineering approach for collaborative product-service (PS) customization filling current gaps and pitfalls. The proposed approach accommodates various complimentary stakeholders' perspectives by fostering view-based modelling of the various aspects of the product, e.g., structural, operational, quality aspects, etc. The PS customization approach is founded on *formalism-based knowledge-intensive structures* called *production blueprints*, which capture rich product-service and production-related knowledge. This enables automated reasoning and inference to validate the consistency of the customizer PS, verify customer constraints and preferences and generate a preliminary production plan. In the heart of the customization approach is the Product-oriented Configuration Language (PoCL), a graphical Domain-Specific Language (DSL) aims at easing the collaborative product design task using the same jargon familiar to customers and other stakeholders, in an abstract and intuitive manner. The bi-directional mapping between PoCL models and production blueprints is defined and is preliminary validated on two real-life industrial pilot cases.

The rest of this paper is organized as follows: related work is summarized in Section 2 and appraised against the work proposed in this paper. Section 3 presents the view-based model-driven engineering approach. Section 4 introduces PoCL and its implementation. The added-value of production blueprints is discussed in Section 5. Conclusions and future work are sketched in Section 6.

## 2. Related Work

Mass customization is a synthesis between mass production and customized goods and services [4]. Pine [4] further distinguishes the following four types of customization: (i) Collaborative customization: firms interact with customers to determine the precise product offering that meets the

customer's needs; (ii) Adaptive customization: firms produce a standardized product that can be altered and customized by the end users within given adaptation limits; (iii) Transparent customization: firms provide customers with unique products without telling them that the products are customized; and (iv) Cosmetic customization: firms produce a unique standardized product and market it to customers in different ways.

According to Joergensen et al. [7], the successful implementation of a customization strategy must include important factors such as: understanding the market needs, creating a modular product platform, postponement of variety until actual demand arises, and establishment of flexible production processes. Collaborative and adaptive customization are especially important for our objective as well as the factors described in [9] as they address the alignment between the market demands, the design of a product and the effective setup of production.

A product architecture describes the decomposition of a product into product modules and the arrangement and explicit interfaces between these modules [8]. Product architectures, also called product platforms, enable the development of product families and generations of products, using shared assets to enable cost-effectiveness. These shared assets also provide many operational benefits, for example, in parts sourcing, manufacturing, and quality control. A product family comprises a set of variables, features or components that remain constant in a product platform and from product to product. Platform-based product family design has been recognized as an efficient and effective means to realize sufficient product variety to satisfy a range of customer demands in support for mass customization [9].

To keep the cost of products close to that of mass production, customization is assured via modularity and commonality in product design. The ability to replace one module with another without changing the interface on either side is key to the effective creation of a product variety. In the design phase, commonality primarily acts to reduce the types of efforts required to produce a product variant [10]. Tian et al. [11] argue that in the case of mass customization a parameterised method may be used to plan the processes of the products and parts since great similarities exist between the products for mass customization and their components. In the parameterised process planning, process is automatically generated based on the values of the corresponding variables.

Research related to product customization has also focused on knowledge intensive models for representing product family platforms [12-14]. Zha and Sriram [12] present a module-based integrated design scheme to support product family architecture modelling, product platform establishment, product family generation, and product variant assessment. The information and knowledge-modelling system in this publication can be used for platform product design knowledge capture, representation and management and offer on-line support for designers in the design process. Several research works have concentrated on the concept of customer-centric enterprise to focus all company operations on serving customers and deliver unique value by considering customers as individuals [15]. At the operational level, mass customization and personalization have emerged as leading

Download English Version:

<https://daneshyari.com/en/article/5469991>

Download Persian Version:

<https://daneshyari.com/article/5469991>

[Daneshyari.com](https://daneshyari.com)