Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 16 (2014) 368 – 372

www.elsevier.com/locate/procedia

Product Services Systems and Value Creation. Proceedings of the 6th CIRP Conference on Industrial Product-Service Systems

Use of Cloud Services in Functional Products: availability implications

John Lindström[a*], Magnus Löfstrand[b], Sean Reed[c], Ahmad Alzghoul[b]

[a]*Computer Aided Design, Luleå University of Technology, 971 87 Luleå, Sweden*
[b] *Uppsala University, UDBL, 751 05, Uppsala, Sweden*
[c]*NTEC, University of Nottingham, Nottingham, UK*

* Corresponding author. Tel.: +46 920 491528; *E-mail address:* john.lindstrom@ltu.se

Abstract

The paper addresses the potential use of cloud services in Functional Products (FP) and its possible implications for availability. Further, how the implications for availability can be understood via modelling and simulation is addressed. The paper adds further specificity to literature by indicating the FP constituents for which cloud services are applicable and adequate.

Selection and peer-review under responsibility of the International Scientific Committee of "The 6th CIRP Conference on Industrial Product-Service Systems" in the person of the Conference Chair Professor Hoda ElMaraghy"

Keywords: availability; Cloud Manufacturing (CMfg); Cloud Services; Functional Products (FP); implications; Product-Service Systems (PSS).

1. Introduction

The emerging trend of using cloud services [1], e.g. Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), or Infrastructure-as-a-Service (IaaS), has reached the manufacturing industry and seems appealing for providers of advanced offerings such as Product-Service Systems (PSS), Industrial Product-Service Systems (IPS^2), Functional Sales (FS) and Functional Products (FP). However, as all of the aforementioned concepts can be or are sold, wholly or partly, with a specified level of availability, one important issue that needs to be addressed is what implications the use of cloud services may have for the overall availability. To limit the scope, this paper will only address the potential application of cloud services, and in particular SaaS, in an FP context, where FP are sold as functions with a specified level of availability. According to Löfstrand et al. [2, 3], in an FP context, availability (or functional availability) can be defined as a function of maintainability and reliability, where predictions of the availability and corresponding cost are necessary.

A motivation for using cloud services is to lower costs and necessary management efforts for customers (and providers) by applying an economies-of-scale approach from the cloud service provider side. Another is that cloud services can be globally available via the internet. A further benefit is that general scalability/rapid elasticity [1], availability and cost for management of software are in most cases more attractive in a cloud service scenario compared to using in-house or outsourced services and resources. However, additional aspects of cloud computing, such as security and legal issues, need to be managed to be able to gain acceptance for the use the cloud services in an FP context. The security and legal aspects have recently been highlighted by, for instance, the vivid debate on the US Government/National Security Agency (NSA) tool PRISM, used to survey communications over the Internet, as well as the potential US Government/NSA access to customer data stored in US cloud service providers' data centres. To get a better understanding of the applicability of cloud services in an FP context, the FP concept is explained below.

Selection and peer-review under responsibility of the International Scientific Committee of "The 6th CIRP Conference on Industrial Product-Service Systems" in the person of the Conference Chair Professor Hoda ElMaraghy"
doi:10.1016/j.procir.2014.01.001

FP[1] has been defined by Lindström et al. [10, 11, 12] as integrated hardware, software, service support system and management of operation. The software component grows as the requirements for monitoring, remote management and maintenance and software upgradability become further sophisticated [13, 14]. The software is often integrated with the hardware and service support system and, depending on type of FP, can also be seen as a stand-alone entity providing its own value to the delivery of the function. The service support system is needed to keep the hardware and software operable, and the triad is combined to provide a complete function to customers [6, 15]. Alonso-Rasgado et al. [6] add that the service support system is much more than maintenance, often including decision-making, operations planning, remanufacture and education. Throughout the FP lifecycle, operation of the FP must be managed and developed.

There are numerous publications on cloud services and availability (e.g. [16, 17]), but few that concern the use of cloud services in PSS, IPS^2, FS or FP and the related implications on availability. Mont [18, p4] denotes PSS as a "*system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models*". According to Mont [18], network and infrastructure are needed as inter-organizational changes, such as closer interaction with other actors in the product service chain, and outsourcing create the demand for intermediates, i.e. managing actor relations. Lelah and Brissaud [19] have in a conceptual manner proposed how ICT and networks can contribute to PSS in different configurations in order to get real-time (or close to real-time) information and monitoring capabilities. Instead of defining the frontiers between PSS and ICT as Lelah and Brissaud [19] have, we aim to highlight the possible and necessary integration of ICT in an FP context and the implications for availability. Karlsson et al. [20] bring up the possible use of cloud services in FP contexts for intelligent processing and querying data streams related to monitoring the operation of FP. The monitoring of operation aims to find indications of problems before they occur, and to be able to proactively manage these issues so as not to impair the level of availability. In addition, Karlsson et al. [20] state that connectivity, needed to monitor FP in real time, is a crucial and adequate provision that must be made for communications. Further use of cloud services in PSS or IPS^2 contexts is proposed by, e.g., Hosono and Shimomura [21] related to service design, Abramovici and Aidi [22] in the next-generation Product Lifecycle Management systems, and Meier and Dorka [23] regarding an IPS^2-Execution System (IPS^2-ES) for managing networks of suppliers, fluctuations in the network, adapting to suppliers and real-time planning of resources, in order to achieve robustness in manufacturing. The IPS^2-ES seems similar to the management of operation in FP proposed by Lindström et al. [11], which, among other things, addresses long-term availability matters during the operation of FP.

Currently, there is a lack of research regarding how cloud services can be used in advanced concepts such as PSS, IPS^2, FS and FP, sold with an agreed level of availability. Most of the current research (e.g. [20, 21, 22, 23]) investigates whether it is possible to use cloud services, but not the possible implications for availability. The issues addressed in this paper are the possible use of cloud services in FP, what implications their use may have for FP availability and how these implications may be understood through modelling and simulation.

2. Cloud Services in Functional Products

According to NIST [1], there are a number of deployment models for cloud services, e.g., private cloud (operate solely for one organization), community cloud (shared by organizations that have shared concerns), public cloud (available to anyone) and hybrid cloud (composed of two or more clouds). Thus, the choice of deployment model should be considered in light of the requirements from FP contexts.

In an FP context, according to Lindström et al. [11], software is often integrated with the hardware and service support system and, depending on type of FP, can also be seen as a stand-alone entity providing its own value to the delivery of the function. In addition, software supports the management of operation. Depending on availability requirements and connectivity, the software may be run locally on the site of operation from remote or distributed servers. The ICT-infrastructures needed could be the customer's internal ICT-infrastructure, the provider's, a third party's (e.g. a telecom provider/operator) or a combination of these.

Based on recent research by Lindström et al. and Karlsson et al. [10, 11, 20, 24], Table 1 outlines potential use of software in the FP main constituents: hardware, software, service support system, and management of operation. Further, Table 1 assesses the applicability/adequacy of using cloud services (low, medium, high), criticality for FP function availability (real-time, short-term, medium-term or long-term), and if there might be additional business restrictions such as legal or security constraints hindering the use of cloud services. The criticality for FP function availability of a software solution is defined as real-time if its current performance directly influences the immediate availability of the FP function, whereas it is defined as short, medium or long-term if its current performance indirectly influences the future availability of the FP function.

[1] The concept of FP has similarities with, for instance, Functional Sales [4], Extended Products [5], Total Care Products [6], Product-Service System (PSS) and Industrial Product-Service Systems (IPS^2) [7], Servicizing [8], or Service Engineering [9] in the sense of increasing the focus on soft parts such as services, knowledge and know-how, etc. additionally offered. The FP, originating from hardware aspects, has most commonalities with PSS/IPS^2, Total Care Products and Functional Sales, adding, however, additional complexity development-wise.