The Role of IT for Extended Products' Evolution into Product Service Ecosystems

Klaus-Dieter Thoben, J. (hans) Wortmann

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Klaus-Dieter Thoben[1], J.C. (Hans) Wortmann [2]

[1]Bremer Institut für Produktion und Logistik GmbH (BIBA),
Hochschulring 20, 28359 Bremen, Germany
tho@biba.uni-bremen.de
[2]University of Groningen, Nettelbosje 2, 9747 AE Groningen, The Netherlands
j.c.wortmann@rug.nl

Abstract. This paper elaborates on the notions of extended products and product service systems. It argues that product service systems evolve rapidly into offerings which cross traditional domains of competition, and move into service ecosystems.

The paper investigates the role of ICT in the development of product services systems, and relates the concepts of software-as-a-service and cloud computing to product service systems. It shows that it is almost unavoidable to connect product service ecosystems to larger service ecosystems in other domains. This development has many consequences, opening many areas of future research.

Keywords. Product Service Systems, Cloud Computing, Service Ecosystems, SaaS

1 Introduction

It is well known, that manufacturing industries are increasingly engaged in adding services to their products. Early papers on the subject (e.g. [1]) coined the term *extended products* in relation the notion of *extended enterprise* (see [2]). Later publications (e.g. [3]) emphasized the role of services even further and used the term *product service systems* (PSS), in which products and services are complementary components of an offering. The servitization of industry can be observed abundantly in practice. It is well documented, in e.g. Meier et al. [3]. Regarding the responsibility of the PSS provider of production means, according to Meier et al. three PSS related types of business models can be distinguished. A *function-oriented* business model includes e.g. a maintenance contract in order to guarantee the functionality of the production means for an agreed period of time. In an *availability-oriented* business model the usability of the means of production is also guaranteed. Accordingly, the PSS provider takes over some business processes of the customer at his own responsibility and thus bears a part of the production risk. With the third type of business model, the *result-oriented* business model, the complete responsibility of the production process is transferred to the provider, as the customer pays for the faultlessly produced parts respectively products.

However, although the role of ICT is acknowledged in ongoing research work, it is not elaborated. Moreover, the nature of services (i.e. ICT based services vs. human based services, the role of ICT in the evolution of services, etc.) is not fully explored. Accordingly, it is generally not precisely understood which role is played by different types of services and what role is exactly played by ICT. Therefore, it is not easy to interpret the ongoing developments and anticipate future developments. In particular, the possibilities for service re-engineering in order to obtain remote delivery of services, the possibilities for service automation and the interconnectivity of service networks are not well understood.

This paper will elaborate on the role of ICT in the development of product service ecosystems, and relates the concepts of software-as-a-service and cloud computing to product service systems. It discusses two conjectures, which follow partly from a literature survey and partly from empirical investigations. These conjectures are:

1. Physical products will take the role of an information hub, which creates an extended relationship of value producers with the product. Avatars of physical products may even engage in interactions similar to social networks [14].
2. Services in whatever domain are rapidly connected to services in other domains, creating a service ecosystem which transcends traditional boundaries between domains of life.

The remainder of the paper is structured as follows. After a discussion of the methodology in Section 2, a literature review discusses related work in Section 3 and 4. Section 3 presents an analysis of PSS literature, from which various trends are derived. Section 4 provides an analysis of IT technologies (incl. SaaS and Cloud technology) enabling future developments of PSS. A corroboration of this vision, presented in section 5, is based on likely scenarios of services in the area of mobility. Following these scenarios we will show the role of cloud computing and the necessity of the SaaS developments sketched in Section 4. Section 6 concludes the paper.

2 Methodology

This paper is focussed on application areas where the servitization of physical products becomes manifest. The methodology followed can be described as follows:

1. Based on empirical observations, the two conjectures formulated above were formulated.
2. These conjectures are transformed into more precise research questions, viz.:
    a. Are extended products move to service ecosystems?
    b. What is the role of ICT in realizing this vision?
3. Literature research, both on PSS and on relevant ICT developments
4. Analysis, from two perspectives (PSS and ICT)
5. Corroboration via scenario development in the mobility domain.

3 Literature survey of related work in PSS

As ever more physical products become servitized, new service components are developed and existing service components get re-engineered in order to increase efficiency, profitability, etc. Accordingly services will be decomposed into customized vs. standard services (service modules), remote vs. location-based (“on-site”) services, human resources involved vs. automated services, etc. The servitization of industry can be observed abundantly in practice. In a recent publication Meier et al. [9] propose to use cloud computing as a backbone for the integrated control of PSS.

Boyer et al. [11] propose a product–process–proximity matrix (P3 service matrix) as a framework for guiding research and practice for e-service design. The additionally proposed models of e-service customer retention and e-operations profiling provide ways to examine the impact of the ICT on three levels of the supply chain. Blau et al. [12] propose means to enable a transformation from hard-wired value chains to adaptive service value networks. An approach based on cloud-computing and advanced collaboration spaces is proposed by Camarinha-Matos, et al. [7] for the manufacturing and life cycle support of solar parks. Other authors emphasize developments in relation to Product Lifecycle Management (PLM) including all phases of the value chain and multi product life management [5].

To summarize, the main findings of the ongoing literature analysis have lead to the identification of trends relevant for the evolution of PSS:

- Services in PSS are getting reengineered, customized, automated
- Services in PSS, including human services, become more remote
- Services by electronic delivery are preferred in PSS (except if these services are intrinsically location-bound *and* if human resources are needed)
- Services between different PSS (i.e. different areas of life / business) become rapidly intertwined

4 Survey of relevant IT technologies enabling the evolution of service ecosystems

In the following, concepts like cloud computing, Software-as-a-Service etc. will be discussed. Cloud Computing enables the provision of computing services as a commodity (service). There are often three cloud computing service levels distinguished (Marston et al. [13]):

- IaaS: Infrastructure (computer hardware/networking equipment) as a service
- PaaS: Platform (hardware, networking, operating system and runtime environment) as a service
- SaaS: Software (applications) as a service

The economic basis for IaaS stems from the low utilization of many hardware facilities at data centers [6]. When ICT companies became aware of the huge storage and server capacity standing idle as back-up or redundant facility, they invented *grid* technology to share hardware amongst many users. This shared usage results in lower costs of hardware and energy.

The economic basis for PaaS stems from *virtualization*. This is technology to create one or more runtime environments on top of a variety of hardware. Accordingly, a runtime platform for applications can be offered to customers which meets their needs and can be very scalable.

The economic basis for SaaS stems from the fact that installation of many versions of application software is one of the main cost drivers. The SaaS technology allows software to be installed only once and be used as a service, which can be called when-ever needed. This *single install* technology provides in general substantial coat benefits. In enterprise software, the SaaS principle is more difficult than elsewhere because data must be stored and secured for each enterprise using the service. This requires so-called *multi-tenacy* technology in addition to the earlier technologies.

In general, Cloud computing refers to an all-embracing virtual software (computing) service environment. The essence is to build / move the main parts of the service generation and delivery from the user sites (devices) to the server sites

The overall benefits of cloud computing are decreased maintenance issues, decreased labor costs, increased computing power, increased performance, increased information security, increased software updates and increased storage capacity. However from the perspective of the provider the “single install” principle is a key advantage for cost reduction, whereas the “pay-per-use” principle provides cost advantages for the user.

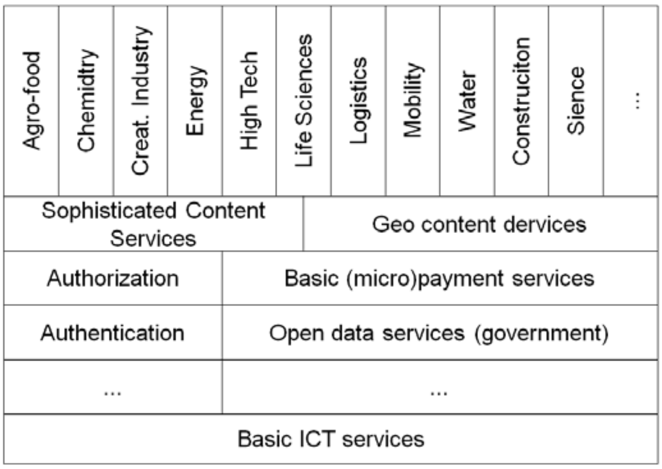

Fig. 1. SaaS Service stack

The extended relationship of the producer with the product triggers continued information exchange. The product will become an information service hub from the producer’s point of view. Accordingly in future software and data services will be architected (configured) with the product and embedded in a SaaS ecosystem. It is expected that IT service stacks will emerge and boost the previously described developments of PSS. A first draft of such a service stack is shown in figure 1.

It is to be expected, that the horizontal layers in the above picture will become available as generic SaaS services across various branches and companies. However, it is also to be expected that vendors of capital goods and industrial equipment will engage in developing new services which increase the value proposition of their offering. These services will initially center around the physical product, which becomes an information hub for all parties with a legitimate interest in the physical product. Such a hub exists on the internet and provides access to related data that also resides on the web.

5 Discussion

To illustrate the role of ICT as well as the findings from chapter 3 for the future developments of PSSs the evolution of a core product into a product service ecosystem is described in figure 2. From the physical perspective the key functionality of a transport device (e.g. a car) is to transport an object from a location A to a location B. From that perspective the first cars had very limited functionalities and provided transportation as the core functionality only. Over the years additional functionalities were added and the car was nicely packaged (designed). Nowadays, where cars have turned into commodities, many people take the transport functionality for being granted. Instead, features such an unlimited availability, the comfort and the safety during the transportation are very much in the foreground of the users / customers and get more attention than before. Whereas the pure transport functionality has to be realized and implemented by physical means i.e. within the physical domain, functionalities like an unlimited availability, the comfort and/or the safety of the customer can be achieved by physical means, human services, IT services or a combination of these assets. For example: extreme expressions of a comfortable transport (taking a car as the physical transport asset) could be a human, acting as a driver (chauffeur), or a fully automated routing of a car from A to B where no involvement of the user is required. By adding services the former core product has been transformed into a so called extended product (see [1]), as shown in fig. 2.

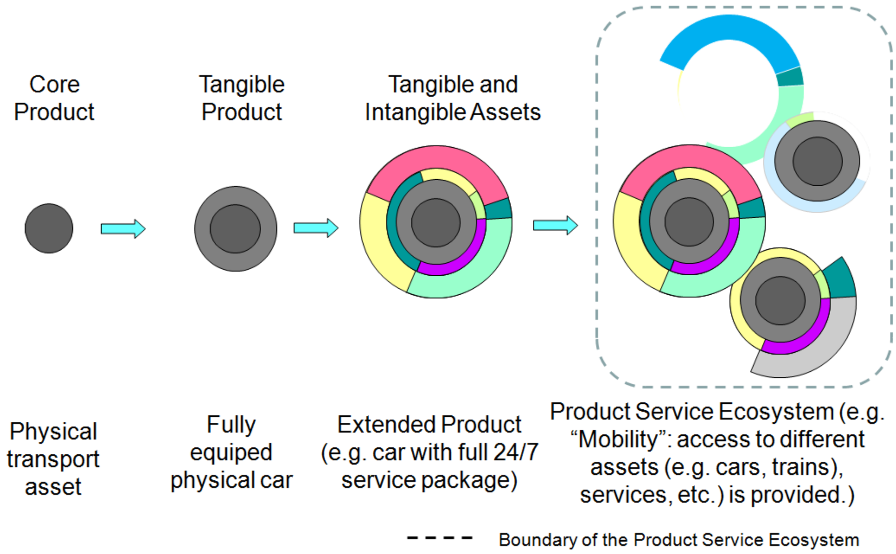

Fig. 2: Evolution from a core product into a product service ecosystem: The case of mobility (inspired by Mejer et al. [3]).

However, when moving the focus from a single transportation process to a *mobility* service, we may sketch new and interesting scenarios, which are likely to be offered in the foreseeable nearby future. Consider for example a traveler in a car which is informed about a traffic jam, due to an accident. The traveler's vehicle may be packaged with a service which calculates the arrival time, and concludes that the traveler will miss his/her appointment. Accordingly, the service may check alternative means of transportation (bikes, public transportation), or may advise the traveler to propose a video conference. The services may direct the traveler to convenient nearby location. If the traffic jam causes the traveler to miss e.g. a plane, the services may automatically inform the airliner and reschedule the air journey.

By integrating and embedding a product into an overall network of products and services a product service ecosystem evolves. Within these environments physical products (take the car as an example) will take the role of an information hub, which creates an extended relationship of value producers with the product. In analogy to the definition of Web-Service ecosystems [15] a product service ecosystem can be seen as a rich, integrated collection of physical products as well as various types of services independent from the nature of the service (human, IT), the art of provision, etc. Product service ecosystems have in common that physical elements are a central part of the system and access these products is provided.

Even this simple mobility scenario can serve to explain why the developments discussed in Section 4 are needed. First of all, an accident and the resulting mobile communication require a very scaleable ICT infrastructure: it is well known, that mobile phones fail to get connectivity in case of a crises. Assuming that there is a sophisticated way to share bandwidth, the ICT facilities need huge scalability, for which *cloud computing* (lowest level of figure 1) is the enabling technology. Calculation of the traffic delay requires *open data* services (for example to know if the road is blocked or open). Access to services such as cancelling and rescheduling appointments requires *authentication*: our wellness would be jeopardized if anyone else can hack our identity. (These services are specified on the next layer in fig.1)

Moreover, the above scenarios require calendars to be accessible for authorized users in a SaaS mode. Accordingly, (sophisticated) *authorization* services are needed. On top of that, services will in general have to be paid for (the current misunderstanding that services are for free holds only if consumers are willing to sell their attention to advertisement), which requires billing services for small amounts of money (micro payments).

Authorization is also needed for sharing other information. For example, the traveler may be willing to share special diet information with an airline company, but not with business partners. Emerging services around personal digital vaults (sometimes called *gems*) allow support of sophisticated sharing of information in a SaaS mode. If the traveler needs health care support, this could be arranged as well.

To summarize, this mobility scenario shows the development of a car as extended product to mobility as a product service ecosystem. This ecosystem comprises a complex, integrated transportation process, different transportation means (bikes, trains, etc.), human services as well as IT services integrated in order to provide a mobility service as an end-to-end process to the customer. By integrating and embedding an extended product into an overall network of products and services a product service ecosystem evolves. This illustrates the transition form the extended product to the *mobility services ecosystem.* The car as physical product becomes an information hub for mobility services.

This development is enabled by the growth of Software-as-a-Service offerings. When the car-related services expand to public transportation, it means that the services of the car service ecosystem link to a different domain, in this case the public transportation ecosystem.

However, there is no reason why expansion of service offerings should stop at the boundary of the public transportation. On the contrary, these service offerings will easily expand to domains such as entertainment, tourism, payment, telecom, health care and other domains.

6 Conclusions and Outlook

This paper has argued that the notion of *extended products* is proceeding towards product service ecosystems. The original ideas related to extended products focused on servitization of the physical product, but without giving due recognition to the delivery of such services.

Meanwhile it is clear that services which *can* be delivered remotely *will* be delivered remotely, at least if the quality of the service is equal in the eyes of the customer. This remote delivery requires scalability and security of IT delivery, which is enabled by *cloud computing* as introduced in Section 4.

Moreover, remote delivery of services is enabled by the SaaS technology. This technology will be boosted by the adoption of generic services in several layers as depicted in Figure 1.

Remote service delivery is greatly enhanced, if services can be re-used across domains. Accordingly, a mobility service which is centered around a traveler's wish for comfortable transportation may lead to services which go far beyond the extended product 'car'. The mobility product service ecosystem quickly links into other domains such as financial services, authentication, health care, etc. This was illustrated in Section 5.

Of course, the vision developed in this paper needs further corroboration. Moreover, it leads to challenging research questions such as related to the strategy of product vendors, the risks involved for vendors and customers, the role of ICT companies, the nature of competition and many other research challenges.

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