

Timing and Targeting of PSS Methods and Tools: An Empirical Study amongst Academic Contributors

Hector Nøhr Hinz, Niki Bey, and Tim C. McAloone

Department of Mechanical Engineering, Technical University of Denmark,
Kgs. Lyngby, Denmark
{niki, tmca}@dtu.dk

Abstract. The emergence of product/service-systems has meant that development methods for such systems have emerged from academia. This paper investigates existing methods that are aimed at developing product/service-systems. Two aspects are determined for each examined method. The first aspect that has been surveyed is *when* a given method is meant to be used in the development of a product/service-system. This aspect has been determined through a qualitative assessment of each method. The second aspect surveyed is *which persons* in an organisation who are seen as the main drivers in the use of the methods. To gain this insight a questionnaire for each method has been conducted with the authors of the methods as participants. The main finding indicates that current PSS methods cannot thoroughly support the development of product/service-systems as their specificity is too low and that the methods need strong intra-organisational collaboration or even roles that do not yet exist.

Keywords: product/service-systems, methods, design, organisation.

1 Introduction

Product/service-systems (PSS) are integrated offerings of products together with services such as repair, maintenance, training or even operation of products. Furthermore the company can have the responsibility of disposing of the product, when it is no longer useable for the customer. In a world with increased competition and scarce resources product/service-systems have come to be seen as a possible way to counter these challenges, if done well. Such integrated offerings mean that a company and its customer will have a transactional relationship that lasts beyond mere product sale. Companies that successfully embrace PSS can have a stable source of revenue and tight ties with their customers, while also having an incentive to make their products as efficient as possible. At the same time, the customer can have stable access to the utility that the products bring, without having to deal with the inconveniences associated with owning a product [1].

When a company wants to offer PSS to its customers it will need to be able to coordinate the features of its products with the services it can provide. Therefore PSS calls for the collaboration between organisational units that concentrate on research and development of products with those units in an organisation that develop and

provide services. Also, PSS requires a company to coordinate with its suppliers, because its ability to provide products, maintenance and other services is also very often dependent on its suppliers [2]. In other words the design of PSS represents an extension of the design activities, when compared to product design [3]. As a research field PSS is still relatively immature, when comparing to traditional product development; there is still a lack of understanding of how PSS should be designed. Based on this insight, the aim of this paper is twofold: First to show where a number of PSS development methods are to be used within a generic PSS development process and use this to analyse the state of existing PSS methods in general; Secondly to investigate who the intended users of the methods are, who are seen as the main drivers of PSS development and what this says about the usability of the methods.

In the following section the methodology of the paper is explained, a definition of what constitutes a method is presented and a general framework for PSS development is established. The analysis gives a short summary of the methods that have been investigated, shows which part of the general PSS development framework each of the methods is suited to and shows who the intended users of the methods are, along with a brief explanation of the authors' view on who should drive PSS development. The discussion comments on the characteristics of PSS development methods and on what the intended users of the methods says about PSS development in general. Finally the conclusion picks up on the work that has been carried out and the results that have been presented.

2 Methodology

In this paper seven development methods are examined with regards to when in a PSS development process they are used and which persons who are going to use them. In order to select development methods for further analysis a definition of what constitutes a PSS method was defined. To be able to assess when the methods are used in a development process, a general framework of PSS development was established, so each method could be compared with it. Thus the goal of the PSS development framework is not prescriptive, but descriptive.

2.1 Definition of a Method

The definition of a method that has been used in this paper is the following: A method is a collection of connected activities that have a finite span in time. By a collection of connected activities is meant that a method consists of a sequence of activities, either in parallel or serial that gives output to another activity until the end activity. For example investigating customer needs is an activity but not a method. The same could be said about formulating requirements for a system. Furthermore investigating customer needs and formulating requirements is not part of a method as long as they are not connected. It is a method only if the output of an investigation of customer needs is used as a basis for formulating system requirements. The span in time is understood such that sequence of activities end at some defined point. When product in use data

is collected as means for informing a design process that ends up with a new PSS that is regarded as a method, but when product-in-use data is continuously used to adjust maintenance schedules it is not regarded as a method, but as a running process.

The definition of what constitutes a method has meant that the analysis has included a number of works that have not specifically been labelled as ‘methods’ by their authors. Furthermore the definition does not in itself deal with the specificity of methods. That is, methods can have a broad scope, such as creating an operational strategy for a PSS or have a more narrow focus as for example a detailed method for the investigating user needs. The specificity of the methods is analysed by comparing them to the general framework of PSS development.

2.2 A General Framework of PSS Development

The framework of PSS development has been created on the notion that since PSS is not a one-time delivery, but a continuous interaction with the customer expanded in the time domain [3]. As such it is possible for a company to keep on altering both products and services even after the customer has begun to receive the offering. The framework is based on the phases found in [4]. It unites some of the phases that are similar and adds a phase called ‘tactical considerations’ in order to catch the activities that lie between the strategic decision to work with PSS and design of a PSS. The framework is shown in figure 1.

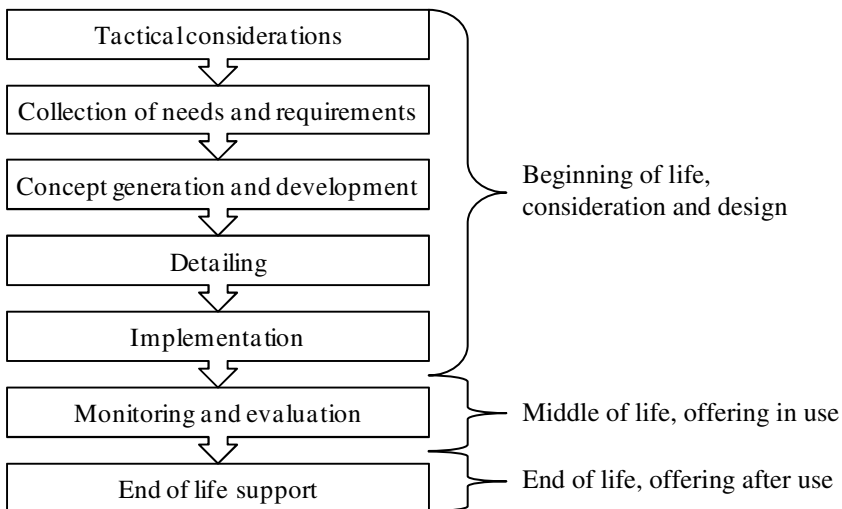


Fig. 1. General framework for PSS development, based on [4]

2.3 The Selected Methods

The methods that have been surveyed have been chosen on the basis of earlier work conducted that has analysed the research of PSS research clusters. The selected methods are either built on existing methods for product development, like Müller and

Stark, Ericson et al. and Matzen and McAloone [5-7], new methods focused on conceptualising PSS in the case of Hussain et al. and Vasantha et al. [8-9], or methods that deal with data collected in a PSS solution, which is the case for Seliger et al. and Sakao and Shimomura [10-11].

The assessment of where each of the methods fit into the general development framework has been achieved by analysing the content of each of the papers that describe the method. The mapping of the intended users of each of the methods has been achieved by conducting a survey with the authors of the papers. The survey consisted of the following three questions:

1. Which persons or departments in an organisation did you wish to target when you developed the method?
2. Did you get input from any persons in companies that are not mentioned in the paper? If so from whom?
3. Which persons or departments in an organisation do you see as the most important drivers for the development of PSS?

Where possible the first authors have been used as main contacts and sources for the survey, otherwise other authors have been contacted and surveyed. The authors have either replied in writing or through telephone interviews.

3 Analysis

3.1 Placement of Methods in Time

In the following each of the investigated methods are analysed with regards to which phases in the general framework for PSS development they follow. This is done by going through each of the methods and justifying how different parts of them fit into one or more of the general activities of the general framework. Even though none of the methods cover all of the activities in the general framework it is not the same as the existence of these activities is deemed unimportant or unnecessary in the methods. It rather demonstrates the specific focus of the methods. In addition to the assessment of the activities covered it is also explained whether an existing system is a requirement for the use of the methods.

The Activity Cycle Model of Matzen and McAloone is a method that makes its users analyse a market situation in order to generate a number of so called views that shows the needs of a customer along with the activities that supports these requirements and the actors that are involved with fulfilling the requirements. Thus the method guides its users to do some early tactical considerations about the actor-network that surrounds the customer without considering the users and their company's own role. Furthermore the identification of needs can be seen as part of collecting requirements. Later on the views are used as input for developing offerings and suggesting network collaborations, which can be considered concept generation and development.

The method for PSS design demonstrated by Ericsson et al. presents a model with five steps for developing PSS where four of the steps are related to modules that are

used in the product development system, TRIZ. The first two steps are to identify needs and identify product characteristics, which corresponds to collection of needs and requirements. The last three steps are all concerned with concept generation and development. The method does not take any input from an existing system.

The model from Hussain et al. is generally applicable to systems where performance needs to be improved. It looks upon an existing system where gaps between customer requirements and the systems capability is first identified by using service blueprints as a mapping method. Thus the method deals with collection of needs and requirements. Then a proposals matrix is used to present and analyse solutions which can service to close the gap between the customer requirements and the PSS capabilities, which in turn represents concept generation and development.

The method of Vasantha et al. presents a number of activities needed to do development of PSS. It is stressed that even though the activities are presented in a serial sequence this is only done for simplicity. In reality all of the activities are interconnected and therefore give output to each other, except for the signing of a contract, which is the final activity that only receives inputs. Two of the activities are concerned with identifying the customer's needs and what is required to meet these needs, which is collecting requirements. Other activities are to identify which tasks are needed to fulfil the customer's needs at both the company that mainly delivers to the customers, as well as at the suppliers, and these are in turn concept generation and development. Finally some of the activities are concerned with developing business models, relegating responsibilities and evaluating solutions, which are regarded as detailing.

Sakao & Shimomura's method starts out by establishing a model that shows the interactions among high-level actors (e.g. companies) based on an existing system. Thus this method actually starts out with what can be regarded as concept generation and development before establishing a number of customer preferences that are equivalent to collection of needs and requirements. In the end the interactions between high level actors is elaborated on further by generating a so called realisation structure which corresponds to detailing, before finally modifying the high-level model to reflect any changes that have been made.

The approach presented by Müller & Stark, which according to the authors should be seen as work in progress, consists of a method based on a product development model. It consists of a number of activities from the initial project planning to the delivery of the PSS, with some parallel activities in the method, where development of services, products and systems take place concurrently. Together all of the activities in the method deal with the collection of needs and requirements, generation and development, detailing and implementation.

The methods that Seliger et al. show are built upon an already existing PSS, where the product has been fitted with equipment used for measuring the behaviour and the performance of the product. The data that are generated are then treated though a number of activities that prepare the data for being used for developing the PSS further. Together these activities constitute monitoring and evaluation.

As it can be seen from the above, a number of activities are covered in the general development framework. A summary of the distribution of covered activities can be seen in Table 1.

Table 1. Activities covered by the seven methods

	Tactical considerations	Collection of requirements	Concept generation and development	Detailing	Implementation	Monitoring and evaluation	End-of-life support	Uses existing system
Matzen and McAloone	•	•	•					
Ericsson et al.		•	•					
Hussain et al.		•	•					†
Vasantha et al.		•	•	•				
Sakao and Shimomura		•	•	•				†
Müller & Stark		•	•	•	•			
Seliger et al.						•		†

3.2 Users of the Methods

In order to provide an understanding not only of the characteristics of the methods but also of their users it was investigated, who were the intended users of the methods, by conducting brief interviews with the authors of the papers, describing each of the methods. For each of the methods a description of the intended users has been received. Along with information of the users the authors have provided information about who have given input to their work in addition to those mentioned in their papers. Thus it is possible to understand the background of the methods. Finally an appraisal of who should be the drivers of PSS development in general was given, which provided a view of the general understanding of the PSS development process in academia. The information that has been gathered is collected in Table 2.

When it comes to the intended users of the methods most of the authors point to a either people or teams with trans-disciplinary competencies or towards a group of people that together form a collection of competencies. With regards to the Systems Engineer and the PSS Architect the authors specifically pointed out, that these roles hardly exist in any companies. As for the sources used for inputs for the methods the answers also shows a lot of different roles have been utilised. With regards to the drivers of PSS the authors mostly point to the managers especially in the beginning of development. In the cases where management is only seen as the initial driver, the authors point to some kind of trans-disciplinary role to take over.

Table 2. Overview of intended users, sources for method and main drivers of PSS development

	Intended users of the method	Sources used for method	Main drivers of PSS development
Matzen and McAloone	Marketing Transdisciplinary teams	Student course Bachelor project Later tried in a number of companies	Initially management, later an independent organisation
Ericsson et al.	R&D Engineers Innovation teams in Advance Engineering or NPD	none	The whole company as PSS is holistic
Hussain et al.	Any stakeholder in any department or industry	Five senior managers in a manufacturer of aero engine components and aero engines Fifteen maintenance experts in various companies	The issues that the customer has in creating their own system Managers
Vasantha et al.	Ideally Systems Engineers working across departments But the framework is meant to be generic	Maintenance Engineers, Maintenance Managers, Maintenance Technicians, Business Managers, Process Developers and Sales People	Business Developers Sales Engineers Contract Promoters
Sakao and Shimomura	Manager of Product Development, Manager of Business Strategy Development, Product Developer, Service Developer, Management Executive in SME	Ministry workers who are working for business cultivation for SMEs and local industries Two company cases	Manager of Business Strategy Development
Müller and Stark	Ideally a 'PSS Architect', but the framework is meant to be generic	Interviews in 13 German companies with various roles. Later experiences have supported the results	Initially management Later ideally a 'PSS Architect'
Seliger et al.	A design team mainly with engineers - knowledge of service is needed in the team	<i>No answer obtained and no input described in paper</i>	Initially management but later the design team

4 Discussion

As it can be seen from the analysis of the placement of methods in time, all but one of the methods deal with collection of needs and requirements and concept generation and development, while detailing is touched upon by three of the methods. Contrary

to this is the remainder of the activities that are either only treated by one method or not treated at all, as is the case with end-of-life support. This indicates that the existing methods for PSS development are still not able to support the development process in all of the phases. This does not mean that the quality of the methods is insufficient though. They might do what they are supposed to do very well and a discussion of the quality of the methods is out of scope of this paper. Rather, the lack of support for some of the activities could indicate that there is a lack of detailed knowledge within PSS research about how these activities should be properly supported and that the specificities of the existing methods are generally low. Furthermore the methods are generic in relation to the characteristics of the PSS solution that has to be developed. In other words, while being generic is certainly part of the point of using a method, it is still noticeable that none of the methods relate to different types of PSS, as for instance found in [12].

A general theme throughout the interviews with the authors is that of trans-disciplinary collaboration. It is a recurring theme within PSS research that the development requires collaboration across different functions in a company. Furthermore some of the authors point towards the need for somebody with a role that spans all involved departments, to use the methods or drive the PSS development. As it has been pointed out this role is rarely found in the companies that work with PSS. This means that there is a risk that some of the advantages of using these methods might be deteriorated by the companies' structures that makes them unable to use the methods in the best possible way.

5 Conclusion

Seven methods have been investigated by comparing them to a general framework of PSS development and by interviewing their authors about the intended users of the methods. The knowledge this has generated has been used as a basis for an evaluation of the state of PSS development methods. The results indicate that most PSS methods have a low amount of specificity, are highly generic and mostly concentrate of formulating needs and requirements as well as conceptualisation. There is a lack of methods that can support the development of PSS throughout the development process. The methods investigated are mostly meant to be used across a number of disciplines, which either calls for strong collaboration across departments or the introduction of new roles in the companies that use them.

References

1. Tan, A.: Service-oriented product development strategies. Technical University of Denmark, Kgs. Lyngby (2010)
2. Bastl, M., Johnson, M., Lightfoot, H., Evans, S.: Buyer-supplier relationships in a servitized environment: An examination with Cannon and Perreault's framework. *International Journal of Operations & Production Management* 32, 650–675 (2012)

3. Matzen, D., Tan, A., Andreasen, M.M.: Product/Service-Systems: Proposal for Models and Terminology. In: Design for X: Beiträge zum 16. Symposium, pp. 27–38. Lehrstuhl für Konstruktionstechnik, Neukirchen (2005)
4. Cavalieri, S., Pezzotta, G.: Product–Service Systems Engineering: State of the Art and Research Challenges. *Computers in Industry* 63, 278–288 (2012)
5. Müller, P., Stark, R.: A Generic PSS Development Process Model Based on Theory and Empirical Study. In: Proceedings of the 11th International Design Conference, DESIGN 2010, pp. 361–370. University of Zagreb, Dubrovnik (2010)
6. Ericson, Å., Bertoni, M., Larsson, T.: Needs and Requirements – How TRIZ may be Applied in Product-Service Development. In: Proceedings of the 2nd Nordic Conference on Product Lifecycle Management – NordPLM 2009. Chalmers University of Technology, Göteborg (2009)
7. Matzen, D., McAlloone, T.: A Tool for Conceptualising in PSS development. In: Design for X: Beiträge zum 17. Symposium, pp. 131–140. Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen (2006)
8. Hussain, R., Lockett, H., Vasantha, G.: A framework to inform PSS Conceptual Design by using system-in-use data. *Computers in Industry* 63, 319–327 (2012)
9. Vasantha, G.V.A., Hussain, R., Roy, R., Tiwari, A., Evans, S.: A Framework for Designing Product/service-systems. In: Proceedings of the 18th International Conference on Engineering Design, ICED 2011, pp. 67–76. Technical University of Denmark, Copenhagen (2011)
10. Seliger, G., Gegusch, R., Müller, P., Blessing, L.: Knowledge Generation as a Means to Improve Development Processes of Industrial Product/service-systems. In: Manufacturing Systems and Technologies for the New Frontier the 41st CIRP Conference on Manufacturing Systems, pp. 519–524. Springer, London (2008)
11. Sakao, T., Shimomura, Y.: Service Engineering: a novel engineering discipline for producers to increase value combining service and product. *Journal of Cleaner Production* 15, 590–604 (2007)
12. Tukker, A.: Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment* 13, 246–260 (2004)