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A COMMON DENOMINATOR FOR PRODUCT SERVICE SYSTEM DEVELOPMENT

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1. Introduction

Products and services have long been combined into integrated offers. In engineering design research, these offers are referred to as "Product Service Systems (PSS)". The question of how best to design PSS in an integrated process (as opposed to designing product and services separately and consecutively) is currently under discussion. The objective is to develop methods for designing PSS with optimal overall performance, taking into account the needs and requirements of a customer, a principal provider and other stakeholders, e.g. suppliers and sub-contractors. Another objective is the realisation of environmental benefits through PSS. Therefore, the scope of the design process needs to be extended to include questions of e.g. distribution of responsibilities for specific processes in the products life cycle.

Researchers at the technical universities of Denmark and Darmstadt (Germany) are involved in this discussion. The material presented here is the outcome of a joint project in which the prerequisites for PSS development at a manufacturer of office furniture were explored. The objective is to identify a common denominator in products and services suitable for design purposes and discuss its applicability in the design process of a company. [Fritz et al. 2007] proposed to investigate their perception of value and utility as integrating factors for the design process. Since it is difficult to relate these terms directly to criteria for design tasks, the integrating links to unite both domains are explored further.

A depiction of product and service life cycles and their intersections is given in chapter 2. The similarities in the nature in designing product and service and their consequences for an integrated development are discussed in chapter 3. Chapter 4 presents the case of the mentioned office furniture manufacturer, in which an application of the concepts has been attempted. The conclusions drawn from the case are presented and discussed in chapter 5 and chapter 6.

2. Modelling of PSS Life cycles

The integrated view of product and services is not so much an issue of a new object to be developed. Industry already combines these two domains in practical work to provide customer value. This resolves in the product development's task to prepare a combined offer that exhibits desired properties when going through its diverse life cycle processes. These properties can be coded into physical artefacts or can be produced through the performance of service activities. For the receiver of the PSS offering the exact mode of delivery is not as important as the fulfilment of his needs and expectations. Consequently, modelling the interaction with and the activities of the user of the PSS offer are central to PSS development, regardless of the mode of the PSS delivery being that of physical artefacts, services or other means.

In order to model the interactions between the PSS elements, we distinguish three levels of resolution:

1. On the elementary level, the single intended interaction or activity must be modelled to understand the effects in terms of functionality, utility, input and output (chapter 2.1).
2. To model the sequence of single processes with the PSS offering, described above, they must be related to each other in a meta life cycle model of PSS delivery elements (chapter 2.2).
3. To model the effect of design decisions on the user's perception of processes in the PSS, a new meta model will be build to understand which parts of a PSS can be influenced and how (chapter 3).

2.1 Modelling single interaction activities within PSS

The individual interactions of a user with the product in space and time, i.e. the life-phase meetings, can be modelled using a transformation process model as presented by [Hubka, Eder 1996]. In the transformation model view, the (technical) means of achieving the modelled transformation is black-boxed, thus leaving it to the designer to define whether the support of the user's transformation should be delivered by e.g. technical artefacts, human operators or other means. The modelling scheme of [Hubka, Eder 1996] separates different types of operators influencing the transformation, namely technical, human, information and management systems. This categorisation aids the designer in defining the necessary development tasks. It supports rethinking, whether the existing solution can be improved by transferring an operator's input to a different category of operation or improve the process performance by adding inputs within a new category. In the preparation for this project it has been useful as a "service transformation process" model for the exemplary description of service processes.

2.2 Modelling the life cycle of PSS delivery elements

The transformation process model seems suitable for modelling the elementary interactions between actor, product (or service proposition) and context. Furthermore, the designer needs to know and influence the customers' sequence of activities. A suitable life cycle model on the conceptual level is depicted in Figure 1.

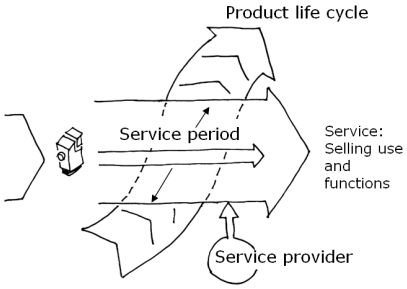

Figure 1. Widening the scope of meetings for which the product is optimised. Redrawn from McAloone and Andreasen [2002]

The model is derived from adapting the Customer Activity Cycle (CAC) model, first presented by [Vandermerve 2000]. Combined with a product life cycle, as a sequence of product interactions, it can be modelled how the sequenced actions interfere and how they benefit from one another. It underlines the necessity of designing not only a physical product (illustrated by the iconic figure on the left), but further the necessity to include the support for the interaction of use in a product life phase along with the active service period of the product.

2.3 Interactions between the two life cycle models

In a PSS, service activities occur parallel to the processes in a product life cycle. The focus is put on the customer by combining the CAC with the transformation model of product use. The combination of the models offers an insight into both product life phases and service activities. Furthermore, a

designer may take advantage of the possible synergies between the product's life cycle and customer's activity cycle. Knowledge gathered on the evolving life cycle of products can thus be utilised to support the customers, e.g. by preventive maintenance.
On the other hand, knowledge on dynamic development of the customer's needs can support the adaption of product and service system design, e.g. in terms of configuration options of technology or by means of reconfiguration services. So the starting point for a PSS designer can be seen in the overlap of the two phases as seen in the conceptual overview. However, it has to be kept in mind that CAC only includes customer activities and the product life cycle centralises the product.

3. Modelling product and service similarities

Up to now users were identified as interacting with the PSS offer in a determinable phase of the product's life cycle and in a service period because of their activities. By focusing on the commonalities between product and service, the question is fairly straightforward: What can we design into both products and service that can be perceived by a user while interacting with the PSS offer?
This serves as the starting point for devising a model that connects processes in the PSS life cycle with "designable" similar elements of both products and services. Therefore the following theoretical research explores on how to link the influenceable sphere of a designer or developer of a PSS to the perceivable sphere of a service receiver. The modelling step provides two models relating the perception of the user to that of the designer, with focus on identifying similarities. To illustrate the findings, an Entity Relationship Model (ERM) is used. An ERM is a relational database modelling scheme used to model a system and its requirements in a top-down approach. A theoretical basis for shared definitions of product and service elements was created in this paper based on [Hubka, Eder 1996] and [Andreasen 1980] for products. [Johnston and Clark 2001] are referred to in order to describe analogical elements in a service period. This led to the mutually used definitions of Characteristic, Property, Structure (Behaviour) and Function. The purpose is to address product life cycle elements and corresponding service period elements with the same terminology.

3.1 Product development

In order to illustrate the connection between designable and perceivable attributes of a product (Figure 2), several existing theories and models were drawn on: In his domain theory, [Andreasen 1980] suggests three working domains for a product designer: "transformation structure", "organ structure", and "part structure". They are summed up here as *Structure*. The product realises a technical transformation and is concretised by designing organs and parts. [Hubka, Eder 1996] provides a definition of internal and external properties.

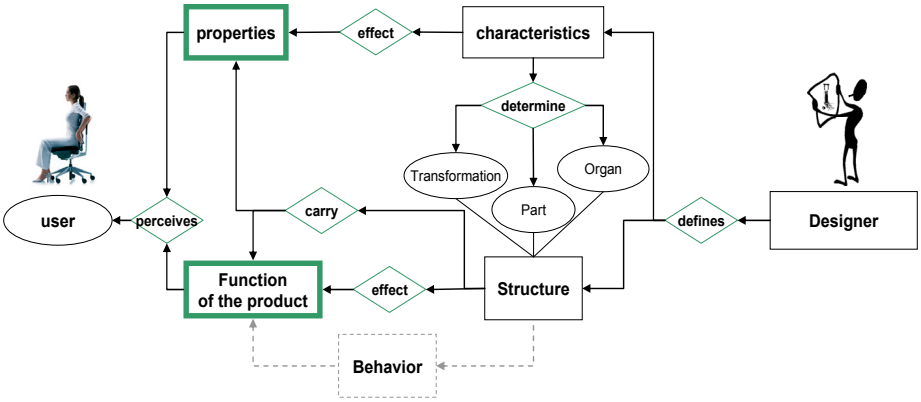

Figure 2. The connection between designer and user of a product

Based on both theories, *Characteristics* are defined as development elements which can be manipulated directly by the designer (corresponding to "internal properties" of [Hubka, Eder 1996]). By defining characteristics of an element, such as dimensions of a part, a designer influences *Properties* as a consequence. *Function* is seen as a representation of the utility (for the user) brought about by the transformation. In this context, the *Structure* provides the means, whereas the *Function* is the end or goal. According to [Gero 1990], structure effects function via the intermediary behaviour. However, some of the content of behaviour seems to be already present in the "transformation structure". The appropriate box in Figure 2 has been added for comparison.
From a designer's viewpoint, designing the elements of the transformation-, part-, and organ structures determines the overall *Properties* of the product and the *Function* exhibited during use.
The user perceives both properties and the function provided to him.

3.2 Service development

The product model presented above is adapted to describe the elements of a service period. Due to the nature of the service processes, receivers experience the service activity only during the service execution ([Johnston and Clarke 2001]). After the activity they perceive the service result. Elements within the service activity, such as human resources, physical objects or environment have certain properties which enter the design process as pre-defined components or boundary conditions. This could be, e.g. the behaviour or set of skills with which a clerk at a hotel reception desk enters into the activity of checking in a guest.

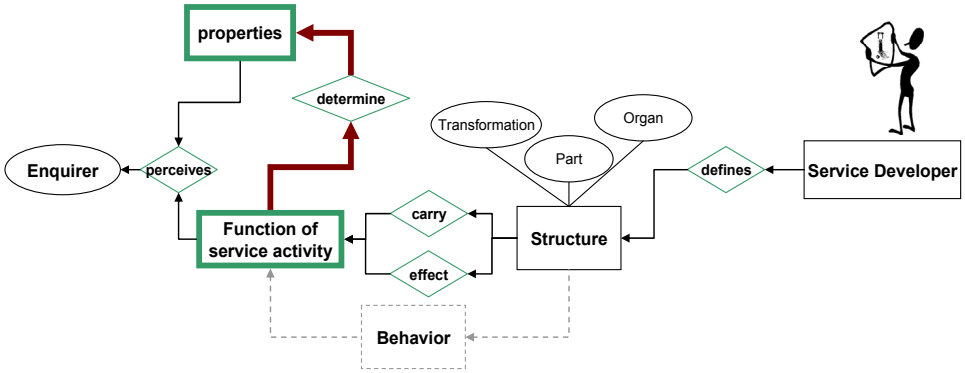

Figure 3. The connection between designer and receiver of a service

Services lack the dimensioning of physical characteristics of products, which may provide the designer with a way to influence properties directly. Instead, the design of a service is represented here as combining structural elements, e.g. a telephone, a computer (with software), and an operator (with specific skills and knowledge), which enter into the activity of providing a service hotline. They do not need to be "re-designed", only arranged in a structure, to fulfil the service. Therefore the structure of the elements determines the function of the transformation process. A "Service Blueprint", as described by [Shostack 1984] may be used to obtain the structure ([Boughnim, Yannou 2005]). It describes the components, activities, and interactions within the service system. In Figure 3, the structure of a service is given as transformation, part, and organ structure, in analogy to the product development model. Since services are activities, it is a combination of a structural and a procedural model.
Service developers define the structure of the elements, not the elements themselves. The structure carries the function. Properties emerge from predefined artefacts and objects arranged within the service activity. The difference to Figure 1 lies in the fact that properties are determined via function and not directly through characteristics.

To summarise the conceptual considerations: Based on the selected references, models showing how designing relates to user perception of the offer has been presented for products and services. In both cases, product and service design, a link between the designable and the perceivable is seen in the function provided to the user. This suggests investigating *Function* as the common denominator between the two. In the terminology used here, characteristics are not applied to services, since service design uses elements defined elsewhere and combines them in a transformation process structure.
The next chapter explores in how far this understanding is shared by practitioners in industry.

4. Case study: using functions to model products and services

Company X is a manufacturer of office equipment and a provider of services supporting office workspaces. Their portfolio includes individualised combinations of products, like furniture and accessories supported by service offers for their integration into the office surroundings. Company X is placed in the upper price range for office furniture. Their main customers are large businesses and organisations, capable of taking advantage of services which amount to the outsourcing of some or all of the workspace management. According to Company X's information, especially long-term customers value the addition of service offers to the portfolio.
The case study takes into account previous research ([Tan 2007]) and serves to complement the research results on Company X's PSS structure as well as exploring how developers derive that structure. By reviewing the data already retrieved from Company X it can be stated that the company is organizing its products in a PSS structure. Core products are the company branded furniture and accessories. Within service, sub-functions and in-company stakeholders were identified.

4.1 Goal and content of case study

The objective of the study was to explore, in which terms development issues are discussed at Company X. Thus it may be determined, whether the assumption, that "function" (in the way it is described above) is a suitable common denominator for PSS development.
Therefore designers and other stakeholders within the company were interviewed. The main focus of the interviews is on identifying how the customer integration is handled and which role product or service functions play.
The interviewees of Company X are working on providing the PSS and can be defined as entering the transformation process of the PSS as human operators, according to [Hubka and Eder 1988]. The topics were chosen to identify how a product and service strategy is derived:

- What does Company X offer to their customers?
- How are services developed within Company X?
- How is product development influenced by its company environment?

Clues towards a practical approach for using function in a PSS development process were expected. A questionnaire was prepared and telephone interviews were conducted with four persons from different departments involved in product development: in product, marketing, company strategy management, as well as in product and service innovation. Each interview lasted 30 to 45 minutes and was accompanied by a set of slides as visual support, issued in advance. The visual support contained theoretical conclusions and propositions on using function, need and value to describe the company's offer.

4.2 The offer of company X described as a PSS

Modelling PSS in chapter 2 suggested function as the common denominator. Selected products and services of Company X can be described exemplarily as sub-functions in a transformation process model, according to [Hubka, Eder 1996]. Some of the operands and operators still need to be verified as not all could be retrieved from the previous research.
One example for the services offered by the company is: Company X conducts extensive surveys of the customer company and its business processes, including interactions between employees and departments, usage and movement of furniture and motion in office space. Thus, Company X comes

into contact with many of the stakeholders involved at the customer company, including managers, janitors and the end-users of the furniture, such as employees and their business customers.
The interviews revealed that company X seeks to develop solutions close to the customer activities. The closeness to their customers is achieved by these on-site explorations. This is accomplished by a specially trained team of internal and external consultants on workspace design, product specialists, ergonomists, and assigned furniture dealers who meet and survey business process over a longer period of time (compare the CAC in [Tan 2007]). Consequently comprehensive knowledge about customer needs relating to workspace setup was built up over the years. Company X identifies the needs and addresses them with a product or service. This source of need identification represents the most important development factor for the company's service portfolio.

Service development

Service provision activities are developed over the years and are product-related and based largely on experience. Needs for service appear during purchasing, usage and after-usage, etc. in all meetings between the company and its customer company. An integrated approach can be identified in working closely with Marketing, Sales and inclusions of the company's management in the decision making on service details.
The service portfolio today consists of standardized service activities which can be combined according to the performance level desired by the customer company. Interactions of customers with products are the impulse for service activity. So the provided service activities are very closely related to customer companies' activities and are developed based on the experience of X's employees within service activities.

Product development

The objective for product development is that (in the words of one interviewee) "every product launched is not supposed to be a product as such but the translation of a solution for a potential issue the customer is addressing." Products are described according to usage and their context of usage by the user, their desired functions, the surrounding environment, and their point of contact with users. This implies that products at company X are defined by their application. They are defined in their activity of an operator interacting with the artefact. This is e.g. the janitor who is in charge of the stock or refurbishment and as well the end-user using it in space and time.
In an integrated approach a so called "Product Charta" is drawn up to frame product development projects. It contains all relevant information on the artefact's desired applications. This description is the starting point for the product development department. Their objective is to meet the "Product Charta" by realizing the described functions with its operators and operands.

4.3 Results of the case study

The interviews yielded the insight that requirements for products and services are collected in a meeting and passed on similar to a description of the product's use context or described by using a model called "Product Charta" in product development. Function, user, environment of usage and desired additional functions are described. So function is a basis for development at company X.
An analogy for deriving requirements for services is seen in the fact that service activities originate in activities of the customer companies during purchasing, installation and disposal. It can be stated, though, that service activities and functions are derived from customer's needs and what they value as useful. Large companies especially appreciate the services by company X according to the interviews. But there is no formalised description, like a "Service Charta", of requirements for service offers yet. Furthermore, it was found that value concepts defined by marketing research, utility, and needs play an important role in drawing up the "Product Charta". They are somehow translated into a functional and an activity based description. These attributes influence the development of services as well. Need identification represents the most important success factor in defining the offering. The value added through services is appreciated by customers

5. Discussion

The subject "PSS" has been presented in terms closely related to design research. In discussing the functional perception of product and service offers with Company X, a connection to practical and organisational aspects of PSS design was made. The interpretation of the results therefore concerns organisational issues as well as issues concerned with the relation and distance between the functional modelling and the reality of product and service design at Company X.

The first factor to be examined is how the product and service offer is represented during the design process. Significantly, Company X is well aware of their customers' activities with their products. This corresponds with a process-centred view, as suggested by the process models according to [Hubka, Eder 1996]. Yet no explicit process modelling is conducted as part of the established design process. Earlier research has demonstrated the potential of employing the customer activity cycle in this context [Tan 2007].

Product development methodology uses functions to approach the design task. Functionality of the product is the end, to which the means are provided in the form of technical solutions or product characteristics. This is mirrored in the procedure Company X employs in order to gather the requirements for their product development. The case study has shown that identification of customer needs leads to a similar perspective on service functions. However, the interrelation of functions in product development theory also constitutes a structural model of the product. One crucial step in integrating the design of product and service into one PSS may be to employ a unified description of the functions of products and services for design purposes. With Company Xs' procedure for identifying customer needs, the basis for this is laid. However, the subsequent steps of requirement formulation are still separate.

The second factor which can be addressed in interpreting the outcome of the case study is the organisational one. Examining service and product development at Company X, one finds that the traditional scope of product development is exceeded in the level of involvement with the customers' business processes. The reason lies in the use of the products offered by Company X. The fact, that the products are an essential prerequisite of the customer's office operation, means that their main requirements appear in processes which are well and conveniently framed in space and time and thus lend themselves to the form of exploration practiced by Company X.

6. Conclusions

The formulation of a "Product/Service Charta" focusing on function as part of the design process could be a goal for future work. In order to judge the practicality of such an approach, the benefits and drawbacks need to be examined. It would be interesting to investigate, to which extent the description of the functions informs the later process of generating and evaluating solutions, and to relate this to the level of interrelation of the product and service portions of the final offer to the customer.

Secondly, the applicability of the approach described above to other businesses has to be critically examined. One of the crucial factors is seen to be the level of interaction with the customer processes.

To conclude, it has to be stated that thinking in functions is not the end of PSS design. Rather, it is a starting point and prerequisite for enabling a company to provide product and service as part of a combined offer.

7. Outlook

An approach for using a functional description for product and service design has been presented. It is founded on models used in engineering design, which have been extended in order to encompass topics crucial to PSS design. The concept has undergone a preliminary test in a company. The results of the interviews employed are not extensive enough to support a final judgement about the practicality of such an approach for PSS design. However, the central conclusion is that thinking in functions is already well established but not explicitly or consciously used within the company, and may in the future be part of the methodical support of the company's PSS design process.

One topic, which has come up during the study, but has not been presented here, is that of the value attached to a PSS by receivers as well as providers. For the receiver, value is the representation of

important and desirable ends he tries to achieve. By focusing on the perceptions of a customer during utilization of products or services offered, Company X reveals that value, needs and function are closely related. A translation from customer value took place in the development process which is currently investigated further.

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