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PRODUCT/SERVICE-SYSTEMS: PROPOSAL FOR MODELS AND TERMINOLOGY

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Abstract

Over recent years a growing number of studies and research programmes have been conducted on the issue of *product/service-systems (PSS)* [1, 2] and results have been presented at this row of symposia [3, 4]. These studies usually analyse the potential of integrated solutions to reduce the environmental impacts of human consumption activity or optimise a company's ability to cope with the influences arising from the emerging globalisation of economic and business activities. Since there has not been worked on a coherent terminology for the terms and concepts used in PSS research, the area remains very blurred and ill defined. This paper will try to identify the fundamental characteristics of PSS and propose a system of concepts that can be used to describe and discuss the phenomenon, for the purpose of developing new PSS solutions.

Coming from a tradition of product development research, the terminology will originate from and be inspired by the German design methodology, *Theory of Technical Systems* [5], *Systems engineering* [6] and the *Domain Theory* [7]. Our considerations will lead to models showing the different development dimensions to be considered in PSS development, compared to existing development models. Furthermore, the models should be able to integrate with the existing models and concepts of new product development.

1 Why PSS and why PSS research?

The ever increasing integration of the global economy and adaptation of information and communication technologies is changing the way companies conduct business. For most manufacturing companies cost, timely delivery and technical quality have traditionally been the main factors in competition when offering products. Companies today are focusing more on how to develop innovative solutions to attract customers, to fit and individualise products and compete on the global market. One innovation strategy that has attained increasing attention the past years is transforming business from being based on the sale of goods to business based on offering a combined product-service system that continuously provides value to the customer. This approach has been dubbed “product/service-systems (PSS)”. The term is related and shared with other terms such as “functional economy” [8], “functional (total care) products” [9] and “service engineering” [10].

The background for the concept of PSS mushrooming these years may be the emerging recognition by many traditional companies that they beneficially could move from product orientation to a more service based orientation, combining product and service delivery. Seen in this light PSS is a metaphor, created by consultants and researchers, for an approach, which has been known and utilised by several types of companies for many decades: suppliers of aeroplane engines, large software installations, transport and logistic systems, etc. From this point of view there is nothing new then, except for the purpose and the way of using PSS.

An underlying principle in a PSS approach is to offer the customer what he really demands, not the ownership but the functionality, utility and performance of the physical product and

services that enhance PSS. All this is delivered while the company maintains ownership and responsibility for the physical artefact. The customer thus pays only for the use of the product when needed and does not have to worry about operation, maintenance and disposal. This enables and motivates companies to reuse, rationalise and enhance their products and services more efficiently throughout their life phases.

An argument often used in favour of development of PSS is the ability to achieve more environmentally sustainable business models, as the objective is to create the highest possible use value of products for the longest possible time while consuming as few material resources and energy as possible. [1] This ability is obtained by linking a higher number of opportunity parameters (Ge: Strategische Handlungsparameter) to the company, giving higher degrees of freedom for influencing environmental problems.

1.1 Description of different dimensions of a complex phenomenon

This paper is concerned with a system of views on PSS, to be able to define the necessary dimensions to consider in the course of PSS development. A PSS is a complex aggregation of systems and system dimensions:

- **Integrating strategy amongst business partners**

  What the customer sees as a delivery may be composed of offerings (products and services) from several companies. Each of these companies decides for a PSS strategy.

- **Organisation of development, creation and delivery of PSS**

  The company creates a system development which builds up a system for delivering (over time) products and services. As part of this delivery over time, a channel for the transfer of services is established. The service channel or PSS delivery system is characterised by alertness, constantly ready to assist the customer in his activities. The delivery system is implemented so that the concurrent support of different customers can yield benefits for all customers as well as the providing company. For companies it is a challenge to manage the “front stage” delivery of solutions with the “back stage” development of products that support the delivery.

- **Activities in the system where product(s) and service(s) are used**

  The activities and their effects in a PSS are the value carriers of a company’s offering. The functions and quality of how they are delivered and perform determine the value on which a company bases its business. From the customer viewpoint, the PSS activities must yield a higher value than competing offers. Therefore the product offer’s function and quality must be well aligned with the demands of the customer.

- **System interaction and relationship between company and customer**

  The customer integrates the offer into his system development and his support system and utilises the PSS over a time period. The provider’s and the customer’s activity systems are aligned through out the service period of the PSS, demanding continuous adjustments of interactions. Through the transfer of responsibility of the product offer from customer to provider, the customer can focus on other issues of his operation. At the same time, the customer must assess the performance of the provider’s services.

The PSS-approach, illustrated as a complex aggregation of systems may therefore be identified or defined by defining the contents of the cuts shown in Fig.1.

Figure 1: The PSS-approach as a complex aggregation of systems. Each cut shows different dimensions of PSS.

1.2 Case used throughout this paper

To give an actual example of what a PSS can look like, and how it fits into the concepts and models presented in this paper, we have chosen a business division of the Danish company Danfoss A/S as a case throughout this paper. This case is an example of a PSS established in a business-to-business (B2B) environment. The models presented in this paper will reflect this, but we will discuss later on how if this may be considered for business to individual consumer relationships.

Danfoss A/S produces components for the refrigeration industry, traditionally as a sub supplier of OEM producers of refrigerators and refrigeration contractors. In recent years Danfoss has built a PSS based on the retail refrigeration market. Through a venture company, Danfoss Retail-Care™ now approaches supermarkets directly. Danfoss refrigeration components and systems have the ability of network communication enabling monitoring, efficiency optimisation and failure detection through electronic networks. Utilising this technology, Danfoss offers refrigeration services to supermarkets on a global scale, promising optimised reliability and energy efficiency. To realise this promise, Danfoss sets a number of different systems in operation:

- The company installs refrigeration systems in the customer's retail supermarket. The components of this installation are partly manufactured by Danfoss, partly delivered by partners of Danfoss. The installation work itself is usually carried out by companies partnering with Danfoss.

- The installed refrigeration systems are connected to a worldwide network, enabling Danfoss technicians continuous monitoring of the system's performance. This monitoring network gives Danfoss the ability to detect threatening system failures at an early stage.

- On a regular basis Danfoss sends performance reports to the customer, giving advice that aids the customers to optimise the operation of their plant.

- In case of failure, Danfoss sends maintenance technicians to the affected plant. The technicians will usually be informed of the type of failure by the monitoring experts, enabling them to quickly repair the customer's plant. In the optimal situation, the

plants operation (concerning the refrigeration of goods) is not affected by the breakdown of components.

- In the contract between Danfoss and the customer, the expenses saved by the optimised plant operation are usually split between the customer and Danfoss over a defined period of time. Hereby both customer and Danfoss have an incentive to cooperate on the optimisation tasks.

2 Basic views on PSS

Commencing a journey into the research of integrated product and service development, the first issue to consider is the difference between product and service, and whether these terms are adequate for describing the phenomena considered. Following a business oriented approach, a service offer might be defined as product, in the same way as a product's usage might be defined as a service to the user. Though different, products and services are both modes of delivering satisfaction, each with its specific set of artefacts, context and consumer behaviour.

Acknowledging the different definitions and viewpoints throughout media and academia, we will present a basic representation to illustrate the phenomenon of product/service-systems. Later, this basic representation will be enriched by other views, applicable as working models for specific purposes.

Hubka [5] has provided us with a model, which proves important here, namely the model of a transformation system, i.e. the operators and operands and their transformation process, see Figure 2. The model describes what happens in time and space when the product is used. Using the concepts of utility (De: Nutzen) and effort (De: Aufwand), Franke [11] develops a similar model, defining transformation of operands as purpose of activities.

Figure 2: Hubka's model of a transformation system, describing what happens when we use the product in time and space [5].

The transformation system (Handlungssystem [6]) or activity system characterises the product offer, i.e. a supply of artefact systems (Sachsysteme [6]) which are used as part of the transformation process, and thereby contributing to fulfilling the needs of the customer. A service is "something" taking part of or influencing the customer's activity. This "something" might be adding or substituting some of the customer's operators and supplying accessories. The interaction between the provider's and customer's activity systems is illustrated in Figure 3.

Figure 3: The product offer seen as adding dimensions to the transformation process.

Seen from the company viewpoint there is a difference between the physical product that is supplied to the customer and the operation of the servicing activity. While physical products (artefact systems) are produced in a production facility (activity system), services are activity systems themselves, yielding benefit to the customer in the course of the production activity.

One may imagine a traditional production company, producing a single product. In this case, the company operates their production facilities (activity systems for production of artefacts), yielding physical products (artefact systems) that are then offered in the market. The market offer thus only encloses the transformations the physical product may aid the customer with. A traditional service company on the other hand, brings a product offer to market only consisting of a number of services. In this case, only activity systems for the delivery of services are present.

Consequently, the *product offer* is the package offered by an organisation to their potential customers. The customers might react on the product offer by entering into a relationship with the organisation, i.e. purchasing the product package. The organisation, who is the provider in this relationship, supplies the customers with a combination of *physical products* and *services*. In the following list, the characteristics of the three elements are shown.

- The product offer is the package of physical products and services, that the provider company (or organisation) puts at their customers disposition. The product offer is the organisations promise to fulfil a (possibly heterogeneous and diverse) need the customers are expected to have in a defined market space, usually in exchange for a defined payment. The product offer represents an activity system. In case of the Danfoss Retail-Care™ system, the product offer is (in short terms) the promise to continuously maintain a stable temperature in the customers refrigerated storage areas, ensuring the best possible energy efficiency.

- The physical products are the physical artefacts (both physical and intellectual assets) put at the customers exclusive disposition. The physical products need not be owned by the customer. The physical products are themselves the result of activity systems in the company's supply chain. In the Danfoss Retail-Care™ system, the

physical products include valves, cabinets, control electronics and the like. Furthermore, performance reports and other documents (partly based on the common statistical data from all customers) are also physical products, exclusively produced for and delivered to specific customers.

This interpretation of the physical product as part of the offer is in accordance with Mont [1]: “A product is a tangible object produced to fulfil consumer’s needs.”

- The service component of the product offer consists of human and product based, more or less automated services, shared between the customers in the PSS. A service can be the maintenance of a physical product, teaching of good practices by the provider’s experts, a common information database, available to all customers or the provision of general services. Danfoss Retail-Care™ services include the initial setup of the refrigeration systems, the periodical analysis of performance conducted by Danfoss technicians, maintenance work executed on site and consultant services on the dimensioning and reconfiguration of refrigeration systems.

  Mont [1] defines: “A service is heterogeneous, mainly an immaterial and perishable activity or process offered by a company or an institution and consumed at the same time as it is produced.” Traditionally services have been distinguished from physical manufactured products by the following characteristics: [12]

  - Intangibility: Customers cannot experience the result before purchase.
  - Inseparability: Services are produced and consumed at the same time.
  - Variability (Heterogeneity): The quality of services varies more than with goods (depends upon who, when, where and how a service is provided).
  - Perishability: Services cannot be stored for later use.

In this paper we will focus on the aspects derived from the difference of the customer’s timing and involvement in development and delivery of PSS characterised by the simultaneous production and consumption.

3 Developing and delivering PSS: The system

Above we looked isolated upon the product offer, which is one of the dimensions in the model Fig. 1. In the following we will try to unfold the other views, i.e. how the creation and delivery of PSS looks like seen from the supplying company and from the customer’s viewpoint.

In traditional manufacturing companies production and consumption are usually clearly separated. A characteristic of services is the production and consumption is simultaneous. In PSS the production or operations organisation will have a direct contact and involvement with the customer when creating and delivering the product offer.

Inspiration for a PSS view may come from the model of product development used in the RAPID project in Finnish industry [13]. The model makes a clear distinction between three types of activities:

- A strategic business/product planning process, where new company approaches are launched, for instance a decision about PSS approach.

- A product management activity, where ideas, customers and strategies are merged into identification, development and commercialisation of new developments.

- A project oriented product development activity, leading to ready sales and production abilities.

The PSS approach changes this pattern because the service delivery may be expanded in a series of deliveries over a longer time span. The service function in the company may be defined as a continuously producing department, in steady contact with the customer, observing the situation and the state of the customers operation and offering services. An important dimension in the service function is the establishing of a service channel [10], through which the offering and delivery can take place. The service channel's objective is to transfer, amplify and control the service content to the customer.

Fig. 4 shows our attempt to illustrate several of the mentioned aspects of PSS development and delivery:

- Strategic business/product planning in cooperation with networks and service partners, i.e. development of the PSS concept.

- Product management and product development projects leading to new PSS offers, i.e. development of the product offer

- PSS delivery system or function, which in steady relation to the customer delivers services, i.e. offer customisation and development of the service channel.

The customer's organisation may show the same organisational pattern as the provider's, but typically focused on a different chain of transformations. In section 5 we will introduce strategic and operational alignment between provider and customer, illustrated by folding the figure along the mid axis. An interesting aspect of this alignment visualised in the folding of the model is that the customer may be considered just as much a partner in the network of the whole PSS. This leads to the idea of PSS as a long term business strategy based on value co-production amongst partners.

Figure 4: The PSS approach leads to a more complex organisational structure of new product/service development and the delivery of services. The figure may mentally be folded in the middle, illustrating the alignment of strategy and operation between customer and service provider.

4 Developing and delivering PSS: Setting the activity arena

The activity arena describes the meetings in which the company and partners/customers define and develop the content of the offer and the delivery of the service. In the development process of a PSS, the activity arena can be expanded in several dimensions, compared to the development of physical products. By changing the company's business model towards a continuing responsibility for the physical products, activities in the relationship between company and customer expand in the time domain. By including more of the customer's transformation activities in the product offer, the relationship is expanded in scope and intensity.

4.1 Expansion in the time domain

The relationship between the customer and the company in PSS is often characterised by an expansion in time compared to traditional business based on the transaction of ownership of goods. Traditionally companies only come in contact with their customers during the sale of products and have limited or no contact in the life phases that follow. It is at the point of sale that the economic transaction of value related to a price between customer and company is made.

In PSS the relationship and interaction between customers and company is closer and is often of a longer duration. The service component allows customers to specify and even participate in the creation of value together with the company in a greater degree than with mass produced and sold products. Longer relationships are rewarding in that the company when interacting with customers can gather knowledge of their use, needs and demands and make use of this in the development of new offerings that strive to fulfil and exceed expectations and thus retain customers. This allows for a continuous value generating relationship for both parties [14, 15].

Since the company retains ownership and responsibility for the physical products over its entire life cycle, the dispositional effects of a product during its meeting with various life phases may be exploited to a much greater extent. The company has greater ability to ensure the product is handled as intended during use, maintenance and disposal in a way that extends the product's life. Furthermore this creates incitement to reuse, refurbish and recycle components of the product to extend the use of material resources even more.

Danfoss' objectives for Retail-Care™ were to move away from being a pure component supplier and establish a closer link between the company and its end-customers (retailers). This relationship would increase Danfoss' knowledge about operational know-how and position them in the provision of value added consultant advice. With Retail-Care™ Danfoss is involved with their retail customers from the design and specification of refrigeration components all the way to the operation, maintenance and management of the entire system.

Global monitoring centres provide remote monitoring of retailers' stores that can detect and diagnose system faults around the clock. By collecting and analysing each store's data Danfoss may also provide a pro-active service that upgrades the system through preventive maintenance and performance optimisation.

4.2 Expansion in the transformation domain

Another dimension in the development of PSS compared to traditional product development is the expansion of the total offering to the customer. Traditional products are developed with a specific defined need in mind. By integrating products and services and managing them as a whole system companies can seek to fulfil broader and higher level customer needs. Integration may occur in two directions, vertically through the value supply chain from supplier to end-user, and horizontally through added value offerings from activities related to the core benefit.

In PSS the extent of the transformation that the entire system performs increases with the degree of integration of products and services. In many cases companies will choose to collaborate with other companies in partnerships to be able to embrace the total offering whilst still maintaining their focus on core competencies and efficiency. Collaboration across companies is a major challenge when designing, developing, implementing and operating the delivery of such offerings. The network of partnerships must constantly find it strategically and operationally viable as well as economically, socially and environmentally profitable in order for them to participate [16]**.** But if companies succeed in managing the entire PSS, new opportunities to provide customers with distinctly competitive total offerings may be developed.

When developing Retail-Care™ Danfoss considered the entire value chain of retail refrigeration and integrated vertically with OEMs, local entrepreneurial contractors and sometimes even competitors, as well as horizontally with energy suppliers, facility managers and ICT providers. This integration was a challenge to the partners' business models and Danfoss had to ensure that all partners had "a piece of the cake". To deal with this Danfoss

established a "Solution venture organisation" outside of their existing components and systems business units. The result is a service offering with a variety of value added levels that fulfil the needs of their customers.

5 Exploiting opportunity parameters by alignment

As stated earlier, the introduction of PSS opens a vast area of potential opportunity parameters. Nevertheless these opportunities can only be exploited beneficially, if the relations of company, customers and product offer are aligned in the right way.

On the operational level, the PSS provider will typically take over most of the customer's activities covered by the scope of the product offer. By transferring responsibility to the provider, the customer's operational departments can focus on their core competencies, while the provider with its superior knowledge of the product offer can ensure optimised operation and minimised operational risk. Furthermore, the close integration between customer and provider yields possibilities of knowledge transfer, enabling the customer to work more efficiently in his own fields of activity.

The provider uses the opportunity parameters of PSS to configure and develop a product offer that yields optimal benefits shared between customers, provider and the provider's partners. The following list illustrates some of the possible opportunity parameters.

- **Optimising the service life of physical assets.**

  The provider will have better and closer control of the use and condition of the physical assets being part of the product offer. This opens opportunities of enhanced service life performance of the products, e.g. by refurbishing worn components and thereby prolonging physical life cycles. By using business models coupling payment to the actual operation of the physical products, possibilities of optimised technical designs arise, normally not feasible in competitive markets.

- **Optimising the operation of physical assets.**

  By the provision of professional service and advice on the use of the physical products, the provider can ensure that products are operating at optimal conditions. This yields opportunities of lower total cost of operation for the customer. Further the virtues of the physical products become more visible in this setting.

- **Aligning interests of customer and provider.**

  By changing the business model to reflect the actual value creation of the customer, the provider is forced to ensure optimised benefit of the customer's operation, aligning the interests of both parts.

- **Expanding the scope of delivery towards the customer.**

  By the integration of activities in the value chain, the provider's position in the marketplace is strengthened.

By aligning the interests of both parts and ensuring optimal utilisation of the product offer, the PSS puts the provider and customer in a situation of partnership, where both parties can work together towards a beneficial development of operations.

6 Conclusion

This paper has attempted to open up on some of the dimensions when considering PSS. In traditional artefact based "product" development it seems that design research has uncovered and is familiar with most of the opportunity parameters we have at our disposition. In PSS development we still seem to be discovering these new opportunities.

Building upon the traditions in product development research we started by looking at PSS in relation to the theory of technical systems. Using the terminology from the theory we then explored various dimensions that characterise PSS. We presented a model of the organisational structure of PSS development including the company, partners and customer. PSS development encourages activity expansions in the time and transformation domain. The concept of alignment of these activities between PSS stakeholders were introduced as a vital component for exploiting the potential benefits of PSS.

The case presented in this paper is an example from a B2B context. Here the customer is an organisation that acts in relation to its own business activities and therefore we may expect an interaction between companies based on professional behaviour. In a business to individual private consumer context we will still expect to see alignment in the various dimensions described between company and customer but the organisation and way of interacting will be of a different nature.

We have proposed various views and models that aid us in structuring and distinguishing the many complex dimensions of a PSS development. The models are far from refined and need to be applied and verified with other cases and aspects of PSS, but hopefully this will be one step which will be a launch pad on which we can continue to uncover the challenges of PSS development.

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